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A Comparison of
the National Training Center and
the JANUS (T) Combat Model Battle Results

by

John P. Gardner

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Thesis Advisor: H. J. Larson

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This thesis compares the weapon systems losses experienced at the National Training Center (NTC) with weapon systems losses in the high resolution combat model JANUS (TRASANA) for the Defend in Sector battle scenario at the Siberia location of the NTC. The scenario is fought between a United States Army Battalion Task Force against a Soviet Motorized Rifle Regiment. The comparison was conducted at both the aggregate and individual weapon system level. The comparison showed that the JANUS (T) model results in a higher number of losses for both the red and blue forces than was observed at the NTC. Additionally, the comparison showed the red force BMP weapon system and the blue force TOW weapon system (both wire guided anti-tank missile platforms) to be much more lethal in the JANUS (T) model than was observed at the NTC. Keywords:

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A Comparison of the National Training Center and the JANUS (T) Combat Model Battle Results

by

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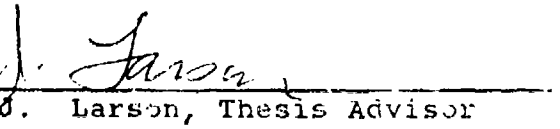
Approved by: 
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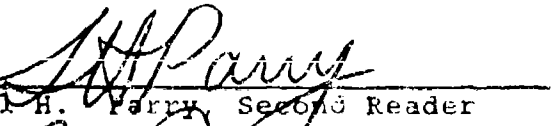
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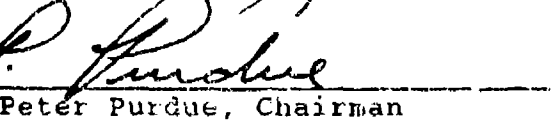
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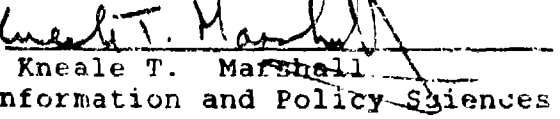
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ABSTRACT

This thesis compares the weapon systems losses experienced at the National Training Center (NTC) with the weapon systems losses in the high resolution combat model JANUS (TRASANA) for the Defend in Sector battle scenario at the Siberia location of the NTC. The scenario is fought between a United States Army Battalion Task Force against a Soviet Motorized Rifle Regiment. The comparison is conducted at both the aggregate and individual weapon system level. The comparison showed that the JANUS (T) model results in a higher number of losses for both the red and blue forces than was observed at the NTC. Additionally, the comparison showed the red force BMP weapon system and the blue force TOW weapon system (both wire guided anti-tank missile platforms) to be much more lethal in the JANUS (T) model than was observed at the NTC.

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I. INTRODUCTION

A. BACKGROUND

1. Nature of the Problem

This thesis seeks to investigate two concerns which face the United States ARMY (ARMY) today.

First, the findings of the Government Auditing Agency (GAO) report, dated July 1986, reported to Secretary of the Army that the data being generated on training results at the National Training Center (NTC) was being underutilized.[Ref. 1] As a result the ARMY established the Center for Army Lessons Learned (CALL), with the mission to catalog, analyze, and disseminate to the ARMY, lessons learned during the training of units at the NTC. In partial response to the GAO finding an existing data base was augmented by the author, which consisted of the results of training battles conducted during the fiscal years 1986 and 1987, by labeling the battles with the following information:

a. Date of occurrence.

b. Location on the Fort Irwin reservation.

c. Mission scenario type.

d. Type of task force (Armor or Mechanized Infantry).

e. The status of task force modernization.

Using this labeling scheme, and the power of LOTUS 1^2_3 software, data can be retrieved under any of the listed categories or combinations of categories for analysis.

Secondly, the JANUS(T) battalion level, combined arms, force on force combat model has not been compared to any known combat results to see if it produces similar outcomes. The main reason is, of course, that there have been no conflicts in which the current Air-Land battle combat doctrine has been utilized. However, the ARMY currently operates a training facility at Fort Irwin, California, which provides as realistic a combat environment as current technology and safety allow.

This thesis compares the battle results of the JANUS(T) model and the battle results taken from the data base at the NTC.

2. Description of the National Training Center

The NTC, located at Fort Irwin, is situated about forty miles northeast of Barstow, California. The military reservation covers over 1,000 square miles of the Mojave desert.[Ref. 2:p. 1] This vast acreage in such a remote location provides sufficient space for full scale maneuver and live fire training of ARMY battalion size task forces.

The current mission of the NTC is to provide tough, realistic combined arms training in accordance with the Air-Land battle doctrine for brigades and regiments.

This training is conducted in a mid to high intensity combat environment, while retaining the training feedback and analysis focus at the battalion task force level. Additionally, the NTC is a data source for training, doctrine, organization, and equipment improvements for the ARMY. The NTC accomplishes this mission through the use of five unique resources.

a. Sufficient land resources to accommodate maneuver for multiple task forces.

b. A permanently stationed OPposing FORce (OPFOR), consisting of approximately 1,500 ARMY soldiers who are thoroughly trained as a Soviet Motorized Rifle Regiment (MRR).

c. An instrumented battlefield which captures objective information on each battle conducted. This information can then be used for the purposes of immediate feedback to the rotational unit, long term trend analysis, and lessons learned for all ARMY units.

d. A full cadre of observer-controllers who plan, control and evaluate the scenario for each battle.

e. Live fire exercises using free maneuver against computer controlled targets.[Ref. 3:p.2]

The combination of these resources allows the NTC to present the rotational unit with a total combat environment in which the unit is challenged, can learn from their mistakes and, most importantly, survive.

3. The NTC Training Concept

The NTC has fourteen training cycles or rotations each year. Each rotation consists of two battalion task

forces, their brigade or regimental headquarters and an appropriate slice of combat service and combat service support personnel. A rotation usually lasts twenty days, of which fourteen days consist of intense force-on-force maneuver and live fire exercises.[Ref. 3:p. 17]

The unique aspect of the NTC is the total immersion of a battalion task force in a combat environment. The overall training experience is based upon a European analog with units exercising emergency deployment plans to depart home station, deploying to the NTC by air and rail transportation, drawing pre-positioned equipment and finally executing battle scenarios of designated tactical missions (deliberate attack, defend in sector, hasty attack etc.).[Ref. 4:p. 3] The training focuses on improving a unit's proficiency in the seven operating systems or areas of performance. These operating systems are air defense operations, command and control, engineer operations, combat service support operations, fire support (artillery) operations, intelligence operations, and maneuver. The training emphasizes a train-evaluate-train model with positive and negative feedback transmitted via detailed after action reviews. Additionally, a final diagnostic after action review is conducted at the end of the rotation and the unit is given a take-home package which contains a

synopsis of the unit's performance for each day of the rotation.

4. The NTC Instrumentation System

The instrumentation of the NTC allows for the transparent collection of objective data from which an assessment of the unit's battle performance can be derived. The instrumentation consists of three major subsystems:

a. Core Instrumentation Subsystem (CIS). The CIS is the heart of the NTC instrumentation system. Its functions include controlling the maneuver exercises, serving as the central data reception or processing station, and assessing indirect fire casualties.[Ref 5:p. 57]

b. Range Monitoring and Control Subsystem (RMCS). The RMCS provides a communications network of automated and human sensors to ensure the observer-controllers the means of monitoring and controlling the activities of both the rotational and the OPFOR units on the battlefield.[Ref. 4:p. 10]

c. Range Data Measurement Subsystem (RDMS). The RDMS provides real time player location and engagement event data on all instrumented players. [Ref 4:p. 10] The RDMS has a series of radio position/location stations, called A stations, installed throughout the ranges on Fort Irwin. These stations communicate with a transmitting unit, called a B unit, installed on both the rotational and OPFOR

units' combat vehicles. By triangulation, (at least three A stations receiving the radio signal of a B unit) the position of each vehicle can be determined, which is then recorded on a computer tape at the CIS.

Additionally, the RDMS, in conjunction with the Multiple Integrated Laser Engagement System (MILES), captures engagement event data or "who shot whom with what". The MILES system is an eye safe laser which is bore sighted to the weapon which it is simulating. A complete weapons hierarchy from rifles to tanks exist within MILES. For example, a rifle cannot kill a tank, but a tank can kill a rifle. The firing of a weapon system results in the generation of both a visible and audible signature, and a laser beam, coded with the firing weapon type, being directed toward the target fired at. Each combat vehicle is equipped with a MILES receiver and numerous laser detectors. Each laser beam carries with it a message of "hit" words and "near miss" words. A hit or near miss is registered with the targeted vehicle receiver based on the strength of the laser beam when it strikes the laser detectors. This is the technical answer to the questions: is the firing weapon in lethal range of the targeted vehicle and is the targeted vehicle vulnerable in the place of laser beam impact?.

If sufficient strength of the laser beam exists to breach an assigned threshold, then a hit is

registered in the targeted vehicle receiver memory. If the laser beam strength is insufficient to break this threshold then a near miss is scored, the vehicle commander is given an audible tone warning him that he is being engaged and the vehicle is allowed to continue. However, if a hit is registered, then a simple Monte Carlo technique is used to determine vehicle damage. A uniform [0,1] random number is drawn by the receiver logic circuits which is then compared to the pre-selected kill probabilities. If the random number exceeds the kill probability a "hit" is scored. Again, the vehicle commander is given an audible tone warning him that he is being engaged and the vehicle is allowed to continue. Otherwise a "kill" is scored, a visible flashing light is activated to inform all personnel on the battlefield that the vehicle is non-operable and the fighting capability of the vehicle is disabled.[Ref. 5:pp.46-49] The receiver then records the type of weapon system which scored the "kill". In the case of an actual miss, no information is given to the individual being engaged. At the conclusion of each battle, these results are recorded for the rotational unit's take-home package.

B. PURPOSE

The purpose of this thesis is two-fold:

First, describe the process of augmenting the NTC data base consisting of the direct fire battle results with the differentiating characteristics of each battle in order that the cataloged data can be easily retrieved and accurately utilized for trend line analysis. With the battle results properly labeled, utilize the data base to identify locations at the NTC where battles have repeatedly occurred. Then replay the NTC position/location tapes of the identified battles to develop a generic scenario for a United States Army combined arms task force against a Soviet motorized rifle regiment for the given battle.

Second, replay the developed battle scenario in the JANUS (T) combat model and, use the data gathered from the JANUS (T) model and the data in the NTC data base to compare the direct fire battle results.

C. SCOPE

This document will make a comparison of the direct fire battle results of the NTC and JANUS(T) combat model. Specifically, comparisons of the total weapon system losses and individual weapon systems losses at the termination of the battle will be analyzed. Individual weapon system analysis will be limited to those weapon systems which are capable of destroying light armored and heavier vehicles.

In Chapter II, the methodology used to modify the data base so that it could be used for this thesis and trend line analysis is presented. Chapter III discusses the detailed procedures for replaying the NTC instrumentation tapes available from the Army Research Institute which show the actual defensive positions and routes of attack to devise a generic defend in sector scenario to be used in the JANUS(T) combat model.

In Chapter IV the JANUS(T) model, the simulation strategy and the procedures followed in implementing the scenario built in Chapter III will be discussed.

Chapter V covers the data analysis and outlines the results. Finally, the conclusions are stated in Chapter VI.

II. NTC KILLER/VICTIM DATA BASE DEVELOPMENT

A. BACKGROUND

As a result of the GAO finding that the data collected at the NTC was being underutilized, the Observation Division of CALL was tasked to start trend line analysis on the seven operating systems or areas of performance using data presently being captured at the NTC. To accomplish this requirement, they automated the killer/victim information on the force on force battles being fought at the NTC from the rotational unit take home packages using LOTUS 1^2_3 as the data base software.

B. DESCRIPTION OF THE ORIGINAL DATA BASE

The original data base was divided into two distinct parts, the red killer/blue victim tables and blue killer/red victim tables. Each table consisted of the victim's weapon systems as the row entries and the victim's starting strength, total victim weapon system losses and victim weapon system losses by killer weapon system type as the column entries. A sample table is shown at Table 1. The data base consisted of a total of 672 tables, representing 336 battles, or two tables per battle.

TABLE 1

ORIGINAL DATA BASE FORMAT

SYSTEM TYPE	START	LOSS	% LOSS	TANK	TOW	DRAGON VIPER	25MM	ATK HELO	CAS	ARTY	OTHER
T-72	40	34	85.00%	22	10	1	0	1	0	0	0
BMP	78	70	89.74%	15	10	2	25	11	3	3	1
BRDM	4	3	75.00%	0	0	0	3	0	0	0	0
SP 122	4	3	75.00%	1	1	0	1	0	0	0	0
MTLB	14	10	71.43%	0	3	0	7	0	0	0	0
ZSU-23-4	1	1	100.00%	0	0	0	0	1	0	0	0
TOTAL	141	121	85.82%	38	24	3	36	13	3	3	1
FRONTAL A	4	0	0.00%	0	0	0	0	0	0	0	0
HIND	0	0	0.00%	0	0	0	0	0	0	0	0
INFANTRY	577	423	73.31%	0	0	0	0	0	0	0	0
SA-14	0	0	0.00%	0	0	0	0	0	0	0	0

C. MODIFICATION OF THE DATA BASE

In the data base's original form, only broad based trend analysis could be accomplished. For example, M60A3 tank killing performance based on the number of Soviet T-72 tanks killed could be tracked over a period of several rotations. However, closer inspection of the data base yielded the fact that not all battles occurred in the same location, had the same mission scenario or the same equipment. Thus the broad based analysis could be challenged based on the simple fact that operations in the defense are significantly different from operations in the offense, yet this distinction was not included in the original data base. Additionally, the research for this thesis would require the identification of a location at the

NTC where a sufficient number of defend in sector battles had occurred so that a generic defend in sector scenario could be developed from the NTC instrumentation position/location tapes. To find this location the existing data base was augmented with the following information for all 336 battles:

1. Date of the battle's occurrence.
2. Location of the battle on the Fort Irwin reservation.
3. Mission scenario.
4. Type of USA task force (Armor or Mechanized Infantry).
5. The status of the USA task force equipment modernization.

The process for researching the date of occurrence, mission scenario, type of task force, and status of equipment modernization was relatively simple, matching the required information of the USA task force with the proper table. The task of specifying the location of the battle at NTC was more difficult. This was accomplished by researching the grid coordinates over which the battle occurred, then plotting these coordinates on a map of the NTC reservation. Finally, the battle location was assigned a name based on the major terrain feature within the plotted grid coordinates. Once the additional information was input into the data base a search for a location with a sufficient number of defend in sector battles, from which a generic

scenario would be developed, could be accomplished. An example of the modified data base is shown in Table 2. This data base can be sorted using the standard LOTUS $1^2 3$ commands to yield any combination of the categories the analyst desires.

TABLE 2

MODIFIED DATA BASE FORMAT

ROTATION	ROT TYPE	TF TYPE	BATTLE TYPE	DATE	LOC NTC	SYSTEM TYPE	START	LOSS	% LOSS	TANK	TOW	DRAGON VIPER	25MM	ATK HELO	CAS	ARTY	OTH
8610	NON MOD	A	DIS	860615	SIB	T-72	40	34	85.00%	22	10	1	0	1	0	0	0
8610	NON MOD	A	DIS	860615	SIB	BMP	78	70	89.74%	15	10	2	25	11	3	3	1
8610	NON MOD	A	DIS	860615	SIB	BRDM	4	3	75.00%	0	0	0	3	0	0	0	0
8610	NON MOD	A	DIS	860615	SIB	SP 122	4	3	75.00%	1	1	0	1	0	0	0	0
8610	NON MOD	A	DIS	860615	SIB	MTLB	14	10	71.43%	0	3	0	7	0	0	0	0
8610	NON MOD	A	DIS	860615	SIB	ZSU-23-	1	1	100.00%	0	0	0	0	1	0	0	0
8610	NON MOD	A	DIS	860615	SIB	TOTAL	141	121	85.82%	38	24	3	36	13	3	3	1
8610	NON MOD	A	DIS	860615	SIB	FRONTAL A	4	0	0.00%	0	0	0	0	0	0	0	0
8610	NON MOD	A	DIS	860615	SIB	HIND	0	0	0.00%	0	0	0	0	0	0	0	0
8610	NON MOD	A	DIS	860615	SIB	INFANTRY	577	423	73.31%	0	0	0	0	0	0	0	0
8610	NON MOD	A	DIS	860615	SIB	SA-14	0	0	0.00%	0	0	0	0	0	0	0	0

III. DEFEND IN SECTOR BATTLE SCENARIO DEVELOPMENT

A. BACKGROUND

The Defend In Sector (DIS) mission scenario at the NTC is characterized by a United States Army combined arms (Mechanized Infantry and Armor) task force (blue force) defending an assigned sector of terrain against a Soviet Motorized Rifle Regiment's (red force) mounted attack. The DIS mission allows the blue force commander to distribute his company teams over the terrain to maximize his defensive capability.

B. PURPOSE

The development of a defend in sector battle scenario to be used in the JANUS (T) combat model which replicated as closely as possible the actual battles at the NTC was a critical step in this thesis. A great deal of the validity in the comparison of the JANUS (T) model and the NTC battle results is predicated on the accuracy of this portion of the research. To insure that the best information possible was used a four step process was followed. First identify a location at the NTC by using the augmented data base, and which by virtue of the terrain, would dictate similar blue force defensive positions and red force routes of attack. Second, confirm the NTC data base output by replaying each

battle on a computer graphics screen. Third, plot blue and red force positions on a map overlay of the location specified in steps one and two. Fourth, develop the scenario based on trends exhibited by the plotted data and confirm this scenario with a technical expert from the NTC.

C. DETAILED DESCRIPTION OF THE PROCESS

1. Identification of a Location at the NTC

The identification of a location on which sufficient battles had occurred in order that a generic scenario could be developed was the first step in this portion of the thesis. Using the modified data base previously discussed, a search by mission type "defend in sector (DIS)" was accomplished. The results are shown in Table 3.

TABLE 3

DEFEND IN SECTOR BATTLES FOR 1986 AND 1987

LOCATION	NUMBER OF BATTLES
AUSTRALIA	2
CENTRAL CORRIDOR	26
COLUMBIA	4
DEBNAM	1
HILL 909 SOUTH	1
NELSON LAKE	3
RED LAKE PASS	2
SIBERIA	15
VALLEY OF DEATH	10
WHALE GAP	3

The Central Corridor and Siberia locations immediately stood out as the locations where the most battles had been conducted. Armed with this information, an interview with Major Mike Shadell, senior analyst for the Observation Division of CALL, was conducted. During this interview the relative merits of each location to provide the needed replication of the blue defensive positions and red route of attack were discussed. The Central Corridor, with the 26 observations, was the most likely candidate. However the Central Corridor terrain allows for the DIS scenario to be carried out in many different ways, including red routes of attack from east to west and west to east and numerous dominating terrain features throughout the area on which to position defensive forces. This implied too much potential variability in the player locations. On the other hand, the Siberia location is a plain which gently slopes downward from high ground in the northeast corner. It is bordered on the west and north by the Teifort Mountains and on the east by the Soda Mountains. (see map Appendix A) This terrain dictates the position of the blue defending force to be the high ground in the northeast corner and the red route of attack, which is channeled by the mountains to be from the southwest corner to the northeast corner.

2. Confirmation of the Data Base Output

The next step was to review the position/location data tapes recorded by the NTC instrumentation system in order to confirm that the battles identified in the NTC data base could be used to develop the DIS scenario for the JANUS (T) model. Three battles were immediately eliminated from consideration because the position/location data tapes were unavailable for review. Replay of the 12 remaining tapes showed that two of the battles did not follow the same position trends of the blue and red force and were therefore discarded. Of the ten remaining battles eight were fought with non modernized blue forces and two were fought with modernized blue forces. Since there is such a disparity between the fire power of a modernized unit in comparison to a non modernized unit, the modernized unit battles were also eliminated. As a result the eight remaining battles possessed the necessary similarity of blue force and red force positioning to be used to develop the DIS scenario for the JANUS(T) model.

Since the analysis had reduced the number of battles to eight, the issue of having too small a sample for replication became a critical concern. The NTC data base contained the killer/victim tables through fiscal year 1987. Thus, a special phone request was placed to the Observation Division of CALL located at the NTC for the killer/victim

tables of the first quarter of fiscal year 1988. This resulted in the identification of two additional battles which had occurred at the Siberia location of the NTC. However since they were such recent battles, the position location data tapes had not yet been archived. Therefore confirmation that the battles had occurred in accordance with the "typical Siberia Scenario" was accomplished through plotting the assigned defensive area on the map to insure it encompassed the correct terrain and through discussions with the personnel at the Observation Division at the NTC. This resulted in ten battles from the NTC being used for the analysis in this thesis.

3. Blue Force Company Level Positions.

The prior step had confirmed the blue battalion task force defense position; however, development of the DIS scenario for the model requires company level resolution. To accomplish this, the eight position/location tapes were again reviewed. During each battle's review, the grid coordinates of the individual equipment pieces for the blue force were transferred from the computer screen to a map overlay of the Siberia location. Company defensive positions were then drawn around groupings of vehicles. The eight overlays were then superimposed on each other and generic locations for the blue force companies were determined.

4. Red Force Routes of Attack

A similar method was used for determining the routes of attack for the Soviet Motorized Rifle Battalions (MRB) of the red force. The grid coordinate position for each MRB was taken at ten minute intervals over the course of each battle and plotted on the map overlay for the Siberia location. This yielded a route of attack from start to finish of each MRB for each battle. Again the overlays were superimposed on each other and a generic route of attack for the red force was established.

5. Technical Expert Confirmation of the Developed DIS Scenario

The final step before inputting the DIS scenario into the JANUS (T) model was to confirm the analytical work with the technical expert from the NTC. This was done through an interview with LTC Peter Manza, Battalion Commander of the Opposing Force during the period 1986-1988. LTC Manza reviewed the battle graphics of the generic scenario and confirmed that the scenario was in accordance with his experiences over the past two years. Agreement between the objective analysis and the trained judgment of the local commander indicated the scenario was appropriate for input into the JANUS (T) combat model.

D. DISCUSSION OF THE GENERIC SCENARIO

The battle graphics which depict the generic scenario for the DIS battle in the Siberia location of the NTC are shown in Appendix B. The graphics show the mechanized infantry combined arms teams on the flanks with the fire power of the Armor company combined arms teams in the middle of the battalion task force position. The anti-tank company is positioned three to four kilometers to the rear of the main force to engage the silhouetted red force vehicles as they crest the ridge line at the maximum range of the wire guided TOW weapon systems. The red force engages the southern flank of the blue force defense in an attempt to destroy the bulk of the blue task force with as little damage to itself as possible.

IV. THE JANUS (T) COMBAT MODEL

This chapter first provides a general description of the JANUS (T) combat model and then discusses the procedure of implementing the generic defend in sector scenario developed in Chapter III in the JANUS (T) model.

A. MODEL DESCRIPTION

The JANUS (T) combat model is an interactive, two sided, closed, stochastic, ground combat simulation. Interactive means that the individual military analyst is responsible for controlling, positioning and movement of his force and does so throughout the sequence of the simulation, based on the combat situation as presented him on the graphics screen. Two sided implies the existence of two opposing forces which are simultaneously directed by two separate sets of players. It is from this attribute that the model gets its name, as Janus was a Roman god with one head and two opposing faces. Closed refers to the model's feature that the disposition of the enemy force is unknown to the friendly force with the exception of the information as provided by those friendly forces in contact with an opposing force. Stochastic means that the events of the simulated battle, such as the firing of a weapon and its

associated result, occur according to the laws of probability and may or may not occur again if the game is repeated. Ground combat refers to the fact that the focus of the model is on those weapon systems that participate in ground maneuvers.[Ref. 6:p. 213]

1. Background of Development

The Lawrence Livermore National Laboratory developed the prototype of the JANUS model called JANUS (Livermore) or JANUS (L) to conduct research on the effects of nuclear weapons on the battlefield. The prototype of the JANUS (L) model was then delivered to the United States Army Training and Doctrine Command Analysis Command at White Sands Missile Range, New Mexico (TRAC-WSMR), formerly known as the United States Army Systems Analysis Command (TRASANA), in January 1983. The code, algorithms, and data base used in the model was then standardized and tailored for Army specific studies. This project resulted in the development and subsequent distribution of the JANUS (TRASANA) or JANUS (T) model.

Currently the JANUS (T) model consists of 85,000 lines of code, written in VAX 11 FORTRAN, a structured Digital Equipment Corporation extension of FORTRAN-77. [Ref 7:p. 22]

2. Model Resolution

The JANUS (T) combat simulation models individual weapon systems which move, search, detect and fire on the ground or in the air over a user specified three dimensional terrain representation. Each weapon system being modeled appears on the graphics screen as an individual symbol. [Ref 6:p. 7] Each symbol must be placed on the terrain, given an orientation, assigned a route if moving, and given an area to search for targets.

The terrain data base includes elevations, roads, rivers, cities, foliage, and barriers. Thus where an actual map shows a ridge line, the same ridge line will appear on the JANUS (T) graphics terminal. [Ref 6:p. 7] Additionally, this ridge line will offer the same cover and concealment to weapon systems as would the real ridge line in actual combat.

Finally, the JANUS (T) model has the resolution and capacity to handle battle scenario sizes up to and including a United States Army battalion task force versus a Soviet motorized rifle regiment. [Ref 6:p. 6]

B. IMPLEMENTATION OF THE DIS SCENARIO

As previously stated, the development and implementation of a defend in sector scenario which was representative of the actual battles occurring at the NTC was crucial to the validity of the comparison of the results

between the two sources. The procedures used and description of the scenario illustrated in Appendix B are the subjects of the following discussion.

The first step was to place the proper terrain file of the Siberia location into the JANUS (T) model. The next step was to initialize the starting strengths of the red and blue forces. This was accomplished by using the number of weapon systems for both sides as were used in the actual battles which occurred at the NTC. Thus ten separate force structures, one per battle investigated, were used over the entire experiment. The starting force structures used in the ten battles are shown in Tables 4 and 5 for red and blue, respectively. The number of weapon systems used in each battle exactly duplicates the NTC data base information.

The blue force was given the doctrinal non-modernized organization for a heavy task force consisting of two armor company teams, two mechanized infantry teams, one anti-tank company and a headquarters company. These elements were placed on the graphics screen according to the positions shown in Appendix B. The individual blue weapon systems belonging to the different company teams were placed within the respective positions so that the line of sight (affecting detection ability) was maximized and directed toward kill zones which covered the most likely enemy armor

avenue of approach. As the blue force was defending, they were placed in hull defilade, or partial exposure, positions which reduced their detectability by the red force.

TABLE 4

STARTING RED FORCE STRUCTURE

	BATTLE NUMBER									
	1	2	3	4	5	6	7	8	9	10
MRB 1										
BRDM	0	0	0	0	0	0	0	0	0	0
BMP	24	30	30	31	33	29	32	31	33	33
MTLB	0	0	0	0	0	0	0	0	0	0
SP HOW	4	5	6	6	6	0	6	6	5	2
TANK	13	13	13	13	13	13	13	13	13	13
ZSU	2	2	2	2	2	2	2	2	2	2
MRB 2										
BRDM	0	0	0	0	0	0	0	0	0	0
BMP	24	30	30	31	33	29	31	31	32	33
MTLB	7	15	18	11	8	13	13	12	11	20
SP HOW	6	0	0	1	1	1	2	2	1	1
TANK	13	13	13	13	13	13	13	13	13	13
ZSU	0	0	1	1	1	1	2	2	1	1
MRB 3										
BRDM	0	0	0	0	0	0	0	0	0	0
BMP	24	30	30	31	32	29	31	30	32	32
MTLB	0	0	0	0	0	0	0	0	0	0
SP HOW	0	0	0	0	0	0	0	0	0	0
TANK	13	13	13	13	13	13	13	13	13	13
ZSU	0	0	0	0	0	0	0	0	0	0
CMD GROUP										
BRDM	2	3	4	3	4	5	4	4	5	4
BMP	0	4	4	4	4	4	4	4	4	4
TANK	1	1	1	1	1	1	1	0	1	1
HIND	0	2	4	3	4	4	6	4	4	4

TABLE 5

STARTING BLUE FORCE STRUCTURE

	BATTLE NUMBER									
	1	2	3	4	5	6	7	8	9	10
MECH TM A										
TANK	4	4	4	4	4	3	4	4	4	3
APC	13	14	14	14	14	14	14	14	14	14
ARMOR TM B										
TANK	9	10	11	9	9	8	10	9	9	9
APC	4	4	4	7	14	14	14	10	13	14
ARMOR TM C										
TANK	9	10	10	9	9	8	10	9	9	8
APC	3	3	3	3	6	6	6	6	6	6
MECH TM D										
TANK	0	3	4	4	4	3	4	4	4	0
APC	13	14	14	14	14	14	14	14	14	14
AT CO E										
ITV	7	7	8	12	14	14	9	17	15	18
APC	0	0	0	2	0	0	2	0	0	2
HQ CO										
MORTARS	5	6	0	5	6	6	6	6	5	5
VULCAN	4	3	4	4	4	2	4	3	5	6
APC	0	0	0	7	0	0	1	0	0	8
COBRA	6	1	0	12	7	5	0	9	7	5

The red force was divided into three motorized rifle battalions and a command group. Two motorized rifle battalions were positioned abreast of each other and constituted the first echelon of attacking forces. The third motorized rifle battalion followed 2,500 meters behind and constituted the second echelon of attacking forces. The regimental command group followed directly behind the second echelon. The regiment attacked with tanks leading, followed by the BMPs in each echelon. The red route of attack shown in Appendix B began at grid coordinate (using the Fort Irwin installation map) NK360000; then moving eastward toward Hill 466 located at grid coordinate NK510010; turning northward toward the finger located in the vicinity of grid coordinate NK521070; at this point turning eastward to engage the center and right flank of the blue force defense; then continuing eastward through the blue force defense and staying out of range of the blue force TOW weapon systems located on the hill top in the vicinity of grid coordinate NK550115.

The probability of kill values assigned to each weapon system in the JANUS (T) model are based on the range at which the firing weapon system engages the target and whether that target is moving or stationary. It is assumed that the JANUS (T) model default probability of kill value

for each weapon system is equivalent to the laser strength threshold required to disable a vehicle in the MILES system.

The detection ability of the participating weapon systems has a direct impact on the outcome of the JANUS (T) battles. In the initial test runs it was found that the default parameters for the detection ability of the red and blue forces heavily favored the blue force. The blue force was so heavily favored that all red force vehicles were being killed without a single blue force casualty. Thus the detection capability of the red force was increased in order that both sides could be attrited on a equitable basis in accordance with their doctrinal capabilities.

The simulation was allowed to continue until all red forces had passed through the blue force position and were no longer being detected or engaged by any blue force weapon system.

C. SIMULATION STRATEGY

Because the JANUS (T) model is stochastic, three runs of each battle were made and the average number of kills per weapon system of the three runs was taken as the JANUS (T) result to be compared to the NTC results. For example, the red tank losses attributed to blue tanks for battle 1 might be 14, 16, 15, respectively, for the three runs. The JANUS (T) result was then taken to be the value (14+16+15)/3 = 15.

Thus fifteen was the number of losses for the red tanks attributed to the blue tanks for battle number one. This method was used for all thirteen weapon systems for the ten battles.

Each battle took approximately one hour and fifteen minutes to run to completion. The data from the battle was retrieved from the model data processor, the game reset and run again. This was a relatively easy, but time consuming process. After each battle a new force structure had to be input, requiring that all new vehicles be placed in their proper company or battalion positions and given the correct orientation.

V. DATA ANALYSIS

The objective of the data analysis was to statistically compare the direct fire killer/victim data resulting from the ten defend in sector battles which occurred at the Siberia location at the National Training Center with the direct fire killer/victim data generated by playing the Siberia defend in sector scenario developed in Chapter III using the JANUS (T) combat model.

A. THE DATA

The data used for this thesis was taken from the killer/victim data base from the NTC and from the killer/victim data output from playing the defend in sector scenario in the JANUS (T) combat model. The defend in sector scenario was played three times for each of the ten battles that were fought at the Siberia location of the NTC. The same force structure for each battle, as reported in the NTC data base, was used in the JANUS (T) model. The three runs of the JANUS (T) model were then averaged and used as the JANUS (T) result. The standard deviations over the three repetitions of the number of losses for each weapon system ranged from 0 to 5.77, with most less than 1.

The data that were used for analysis in this thesis were separated into the following groups:

1. The total number of red and blue force losses per weapon system by battle number.

2. The total number of red and blue force losses for the ten battles by weapon system.

3. The number of losses per weapon system which are attributed to another specific weapon system.

4. The sum total over the ten battles of the number of red and blue force losses by weapon system

These data are shown in Appendices C, D, E and F.

B. TERMINOLOGY USED TO DESCRIBED LOSSES

The analysis is based on the comparison of the number of losses observed at the NTC for a particular rotation versus the number of losses observed in the JANUS (T) combat model using that rotation's force structure in the generic defend in sector scenario. The term "total weapon system losses" refers to the losses of a particular weapon system which are attributed to all of the weapon systems of the opposing force. The phrase "number of losses of weapon system type A by weapon system type B" refers to the number of losses of weapon system type A which are attributed to the opposing force's weapon system type B and does not represent all losses of weapon system type A which may have occurred in the battle. A listing of the weapon systems and a brief description of the equipment's purpose are presented in Table 6

TABLE 6

EQUIPMENT LIST AND DESCRIPTION

RED FORCE	PURPOSE
T-72 (Red Tank)	Main Battle Tank
BMP (Red APC)	Anti-Tank Wire Guided Missile Platform
BRDM	Reconnaissance Vehicle
MTLB	Personnel Carrier
HOWITZER 122 MM	Artillery used in Direct Fire Mode
ZSU	Anti-Aircraft Weapon
HIND HELICOPTER	Anti-Tank Wire Guided Missile Platform

BLUE FORCE	PURPOSE
M60A3 (Blue Tank)	Main Battle Tank
M113 (Blue APC)	Armored Personnel Carrier
M901 (Blue TOW)	Improved Tow Vehicle, an Anti-Tank Wire Guided Missile Platform
M106 (Blue Mortar)	Battalion 4.2 inch Mortar
M163 (Blue Vulcan)	40mm Gatling Gun used for Anti-Aircraft
COBRA HELICOPTER	Anti-Tank Wire Guided Missile Platform

C. MEASURES OF COMPARISON

For each of the ten battles, there were a total of seven red force weapon system types and six blue force weapon system types. Table 7 shows the weapon systems for each force and the weapon systems of the opposing force which they have to capability to destroy.

TABLE 7

DESTRUCTION CAPABILITY OF PARTICIPATING WEAPON SYSTEMS

RED FORCE	LETHAL AGAINST
T-72 (Red Tank)	All Blue Force Weapon Systems
BMP (Red APC)	All Blue Force Weapon Systems
BRDM	All Blue Force Weapon Systems
MTLB	No Blue Force Armored Vehicles
HOWITZER 122 MM	All Blue Force Weapon Systems
ZSU	All Blue Force Weapon Systems except Blue Force Tanks
HIND HELICOPTER	All Blue Force Weapon Systems

BLUE FORCE	LETHAL AGAINST
M60A3 (Blue Tank)	All Red Force Weapon Systems
M113 (Blue APC)	Light Armored Red Force Weapon systems such as BMP, MTLB, HIND and BRDM
M901 (Blue TOW)	All Red Force Weapon Systems
M106 (Blue Mortar)	Light Armored Red Force Weapon Systems such as BMP, MTLB, HIND and BRDM with secondary weapon system
M163 (Blue Vulcan)	Light Armored Red Force Weapon Systems such as BMP, MTLB, HIND and BRDM.
COBRA HELICOPTER	All Red Force Weapon Systems

There is a significant difference in the theoretical capability of a weapon system to destroy another weapon system and the reality of how weapon systems actually perform at the NTC and in the JANUS (T) model. In reality, even though most of the red and blue forces have the capability of destroying the others equipment, the red force tanks and BMPs and the blue force tanks and TOWs are attributed with the vast majority of the direct fire kills on each side. A specific example is the direct fire battle between the blue force APC and the red force BMP. The blue force APC is armed with a fifty caliber machine gun. This weapon has the capability of piercing light armor. The BMP is a light armored vehicle and thus the APC theoretically has the capability of destroying a BMP. However, the probability of the blue force APC destroying the BMP is very low because it requires a direct hit from a 90 degree angle for the round to penetrate the BMPs' armor. Therefore, once the APC engages the BMP, the APC gives away his defensive position and the red force BMP returns fire with a SAGGER wire guided missile resulting in almost certain death of the APC. Hence, in most cases, the APC does not engage the BMP. A similar situation exists for the blue force Mortars and Vulcans and for the red force MTLB and ZSU.

The two aircraft which participate in the battle are the HIND for the red force and COBRA for the blue force.

Both of these weapon systems are very lethal threats; however, they are also very vulnerable to small arms fire from the ground because they are aircraft. The result in the JANUS (T) model is that they may fire one or two rounds which may or may not score a kill. But once they have fired they are immediately detected by the opposing force and because they are so vulnerable, die instantly. On the other hand, the helicopters at the NTC are rarely killed and usually have a five to one kill ratio. This large disparity in the performance of the helicopters at the NTC and in the JANUS (T) model make a comparison meaningless.

Finally, the red force BRDM has the capability to destroy all blue force weapon systems. But its location on the battlefield with the red force command group at the rear of the attacking force meant that by the time it arrived in the battle area, all of the blue forces were destroyed and thus it had no reason to fire. This also occurs at the NTC, therefore since no kills were attributed to the BRDM in the JANUS (T) model and and very few kills at the NTC a comparison was not possible.

Therefore based on the actual engagement practices between the various weapon systems on each side in both the JANUS (T) model and the NTC, Table 8 shows the seventeen measures of comparison that were used to analyze the results of the JANUS (T) model and the NTC.

It should be noted that from this point on in the thesis, references to comparisons will be made by comparison number from Table 8. This list includes comparisons at both the aggregated and individual weapon system level for the weapon systems with the direct fire capability of destroying light armored and heavier vehicles.

TABLE 8

MEASURES OF COMPARISON

1. Total Blue Killed
2. Total Blue Tanks Killed
3. Total Blue Tows Killed
4. Total Blue Tanks + Tows Killed
5. Total Blue APCs Killed
6. Total Red Killed
7. Total Red Tanks Killed
8. Total Red BMPs Killed
9. Total Red Tanks + BMPs Killed
10. # of red tanks killed by blue tanks
11. # of blue tanks killed by red tanks
12. # of red tanks killed by blue TOWs
13. # of blue TOWs killed by red tanks
14. # of red BMPs killed by blue tanks
15. # of blue tanks killed by red BMPs
16. # of red BMPs killed by blue TOWs
17. # of blue TOWs killed by red BMPs

The following four analyses are discussed:

1. A statistical summary analysis using the sample mean and standard deviation of the number of weapon system losses and the ratio of weapon system losses for the JANUS (T) and NTC data. Additionally, the lethality of the blue tanks and TOWs and red tanks and BMPs using bar charts is discussed.
2. Scatter plots of the NTC and JANUS (T) data and the plotted data's relation to the line $Y = X$.
3. Least squares regression of the total number of kills in the JANUS (T) combat model on the total number of kills observed at the NTC using the regression model $Y = \alpha + \beta X + \varepsilon$
4. An examination of the differences in the losses for the JANUS (T) and NTC, for each battle, for each of the seventeen comparisons.

D. STATISTICAL SUMMARY ANALYSIS

The purpose of the statistical summary analysis was to investigate and compare the number of losses for the NTC and JANUS (T) red and blue force weapon systems over the ten battles. Specifically, the data was investigated for information which would support the claim that the JANUS (T) model yielded the same results as were observed at the NTC in terms of the number of losses of each type of weapon system.

Tables 9 and 10 show the calculated sample means and standard deviations, of the numbers of weapons killed. Also given are two numbers labelled lower and upper bound which create an interval about the sample mean. The lower bound is the mean minus one standard deviation and the upper bound is the mean plus one standard deviation.

This analysis showed that for eight of the thirteen weapon systems (blue VULCAN, blue MORTAR, blue COBRA, red HOWITZER, red MTLB, red BDRM, red HIND, and red ZSU) the standard deviation is almost as large or larger than the sample mean. This large variability is explained by the fact that the starting strength and the number of losses for these weapon systems are so low that one battle, where a few are killed, causes the large sample standard deviation in relation to the sample mean. This low number of losses occurs because of the relatively low threat of these weapon systems against the opposing force.

TABLE 9

SUMMARY OF RED FORCE WEAPON SYSTEM LOSSES

RED FORCE	MEAN	STD DEV	LOW BOUND		UP BOUND
TANK					
NTC	16.20	5.47	10.73	TO	21.67
JANUS	29.17	2.42	26.75	TO	31.58
BMP					
NTC	31.10	12.56	18.54	TO	43.66
JANUS	42.57	7.00	35.56	TO	49.57
BRDM					
NTC	1.20	.98	0.22	TO	2.18
JANUS	.03	.10	0.00	TO	0.13
MTLB					
NTC	1.50	2.11	0.00	TO	3.61
JANUS	6.67	2.18	4.49	TO	8.85
HOWITZER					
NTC	1.70	1.79	0.00	TO	3.49
JANUS	0.97	1.26	0.00	TO	2.22
ZSU					
NTC	1.40	1.02	0.38	TO	2.42
JANUS	2.13	0.96	1.17	TO	3.09
HIND					
NTC	0.60	0.66	0.00	TO	1.26
JANUS	2.80	2.04	0.76	TO	4.84

TABLE 10

SUMMARY OF BLUE FORCE WEAPON SYSTEM LOSSES

BLUE FORCE	MEAN	STD DEV	LOW BOUND		UP BOUND
TANK					
NTC	15.70	4.22	11.48	TO	19.92
JANUS	23.03	4.28	18.75	TO	27.32
APC					
NTC	16.70	6.83	9.87	TO	23.53
JANUS	28.10	6.13	21.97	TO	34.23
TOW					
NTC	7.70	4.29	3.41	TO	11.99
JANUS	9.80	6.74	3.06	TO	16.54
MORTAR					
NTC	1.60	1.96	0.00	TO	3.56
JANUS	0.10	0.30	0.00	TO	0.40
VULCAN					
NTC	1.60	1.43	0.17	TO	3.03
JANUS	1.10	0.54	0.56	TO	1.64
COBRA					
NTC	1.20	1.78	0.00	TO	2.98
JANUS	5.17	3.73	1.44	TO	8.90

One comparison of the two sets of data is then given by checking the degree of overlap of the two intervals. In four of the remaining five weapon systems (blue TOW, blue TANK, blue APC, and red BMP) the computed interval for the NTC and JANUS (T) data overlap. This implies that the distribution of the losses might be the same for both the NTC and JANUS (T) data for these weapon systems. In the

case of red tanks the intervals do not overlap. Further analysis of the intervals for these five weapon systems shows that the mean number of losses for the JANUS (T) data is consistently higher than the mean for the NTC data. Thus the JANUS (T) model results in a higher number of kills for these weapon systems than was observed at the NTC.

The conclusion that the JANUS (T) model results in a greater number of losses than the NTC was also derived from an analysis of the ratio of the total number of losses for each weapon system over the ten battles. Table 11 shows that nine of the thirteen weapons systems experienced more losses in the JANUS (T) model than were observed at NTC. The four weapon systems in which more losses occurred at the NTC than in JANUS (T) are not main players in the direct fire battle and thus are lower on the priority list to be destroyed by the opposing side. Additionally, a comparison of the grand total of losses, for both the red and blue forces, of each weapon system over the ten battles showed that 1.57 times more red force weapon systems losses and 1.37 times more blue force weapon systems losses occurred in the JANUS (T) model than were observed at the NTC.

The comparison of the lethality of the four weapon systems (blue tanks, blue TOWs, red tanks, red BMPs) was accomplished by comparing the number of opposing force weapon systems killed by those four weapon systems in JANUS

(T) with the same data at the NTC. Figures 1 and 2 show the lethality of the red tanks and BMPs and Figures 3 and 4 show the lethality of the blue tanks and TOWs.

TABLE 11

TOTAL LOSSES OVER ALL TEN BATTLES

	NTC Total Losses	JANUS(T) Total Losses	Ratio JAN/NTC
Red Force			
TANKS	162	291.67	1.80
BMP	311	425.67	1.36
BRDM	12	.33	.03
MTLB	15	66.67	4.44
HOWITZER	17	9.67	.57
ZSU	14	21.33	1.54
HIND	6	28.00	4.67
GRAND TOTAL	537	834.34	1.57
Blue Force			
TANK	157	230.34	1.47
APC	167	218.01	1.31
TOW	77	98.00	1.27
MORTAR	16	1.00	.06
VULCAN	16	11.00	.69
COBRA	12	51.67	4.31
GRAND TOTAL	445	610.02	1.37

Figure 1 shows that the red tanks tend to be more lethal at the NTC than in the JANUS (T) model. Comparison of the number of kills by red tanks is larger for the NTC than JANUS (T) for all blue force weapon systems except blue tanks and this number is very close. This is a somewhat surprising result because it was just shown that the JANUS (T) has more losses in the aggregate than the NTC. This surprising result is explained by the number of kills of blue force weapon systems by the red BMPs. Figure 2 clearly shows that the red BMPs are more lethal in the JANUS (T) model than at the NTC. Therefore in the aggregate the result is as before.

The lethality of the blue tanks is shown in Figure 3. This figure shows that the blue tanks are more lethal in JANUS (T) versus the red tanks but are more lethal at the NTC versus the red BMPs. This is offset by the substantial difference in the lethality of the blue TOWs. Figure 4 shows that the blue TOWs kill almost three times the number of weapon systems in JANUS (T) as in the NTC. Again the aggregate result is that more are killed in JANUS (T) but it is very important to know which weapon systems are contributing to the differences.

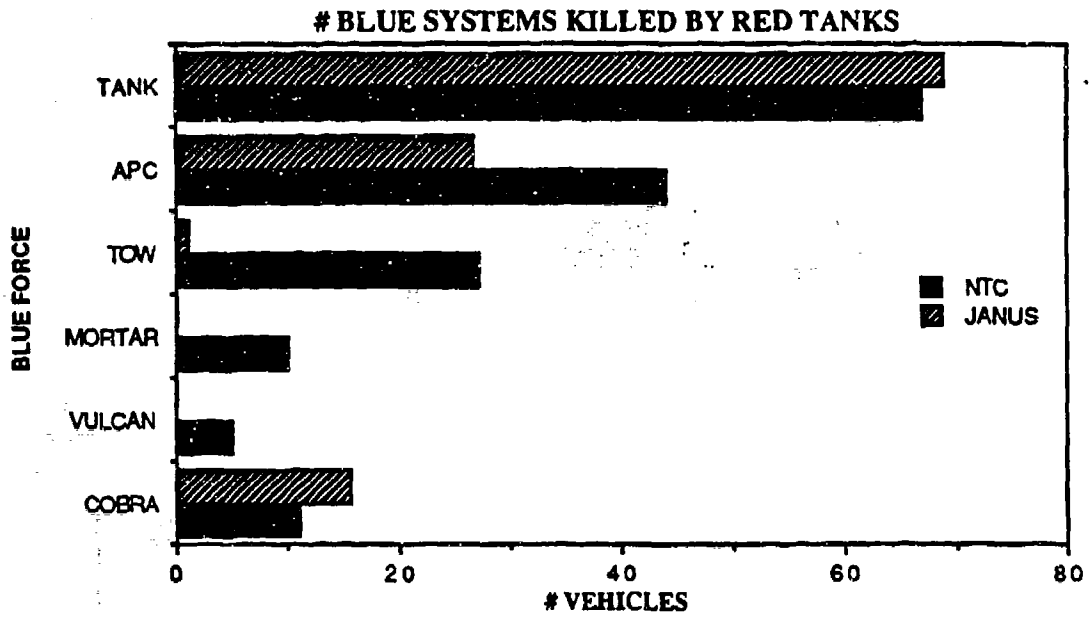


FIGURE 1. Lethality of the Red Force Tanks.

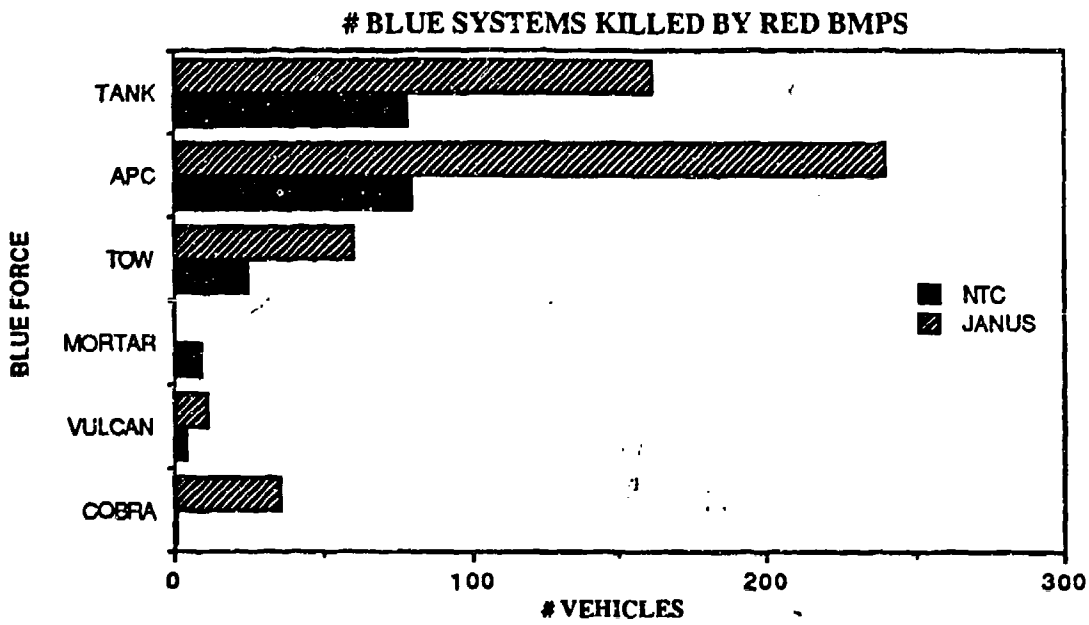


FIGURE 2. Lethality of the Red Force BMPs.

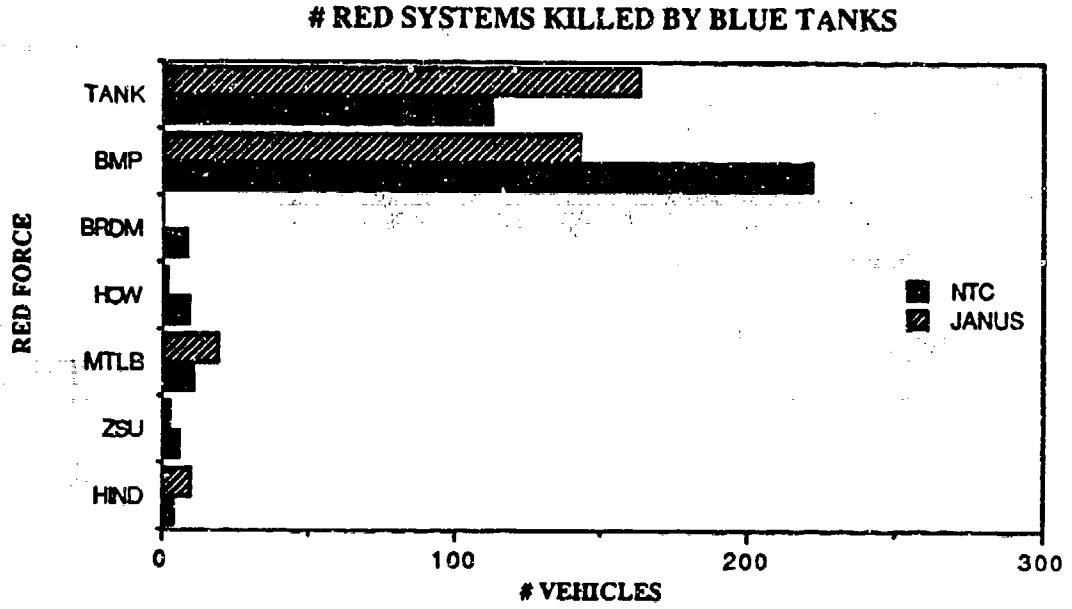


FIGURE 3. Lethality of the Blue Force Tanks.

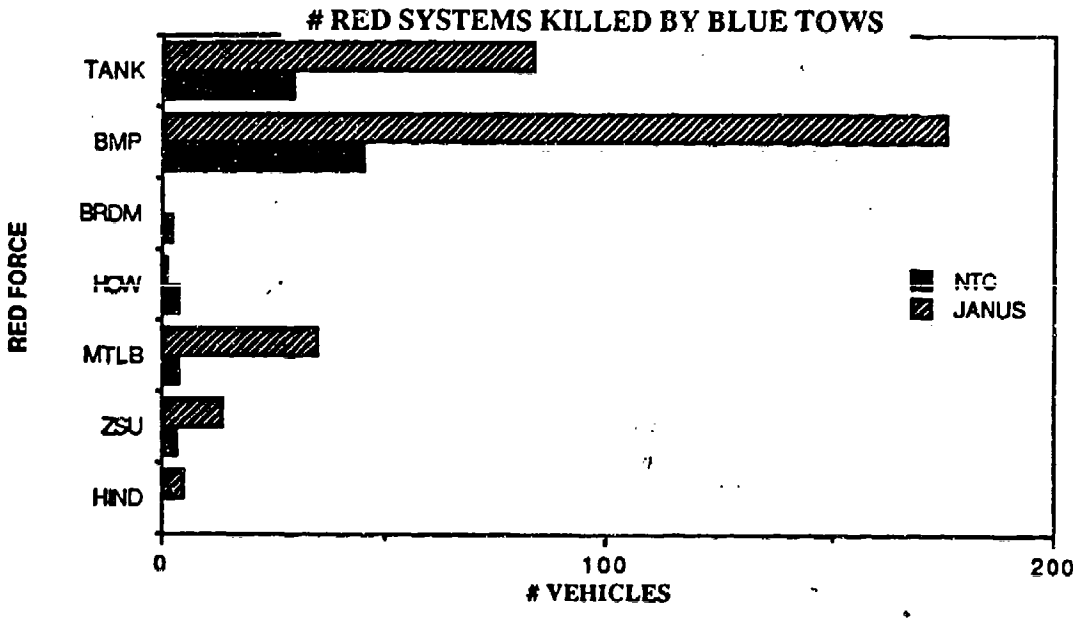


FIGURE 4. Lethality of the Blue Force TOWs.

E. SCATTER PLOT ANALYSIS

The JANUS (T) results versus the NTC results were compared for each battle. The resulting scatter plots are shown in Appendix G. The X axis was defined to be the observed weapon system losses at the NTC and the Y axis was defined to be the observed weapon system losses in the JANUS (T) model. Visual inspection of the graphs shows that the plotted points consistently lie above the line Y = X for 13 of the 17 comparisons. This is more indication that the number of kills in the JANUS (T) model are higher than those observed for the same battle at the NTC. Closer study of the graphs shows that six of the nine comparisons (reference numbers from Table 8 are 1, 2, 4, 5, 11, 15) involving the number of blue force losses show a consistent grouping of data points slightly above the line Y = X. An example is shown for the total number of blue losses in Figure 5.

This indicates the possibility of a correlation between the NTC and JANUS (T) data, with respect to the number of these blue force weapon systems killed.

The three blue force comparisons (3, 13, 17) which did not follow this trend all involve the number of blue force TOW losses. This absence of the same trend in the data for blue TOWs is shown in Figure 6.

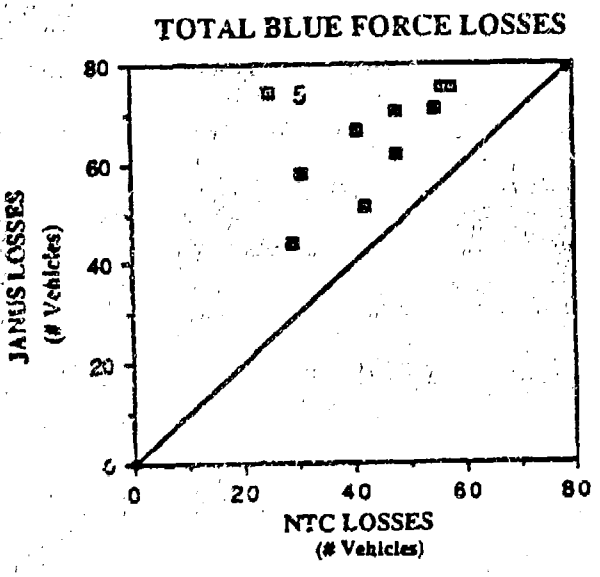


FIGURE 5. Scatter Plot of the Total Blue Force Losses.

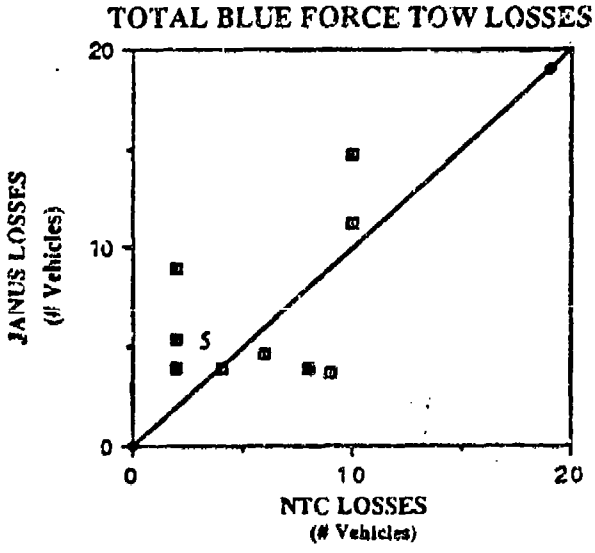


FIGURE 6. Scatter Plot of the Total Blue Force TOW Losses.

The scatter plots of the red force losses do not show a consistent pattern. In fact, the graphs show the plotted points to be spread over a wide range in both the x and y directions. This is shown in Figure 7 for the total number of red force losses.

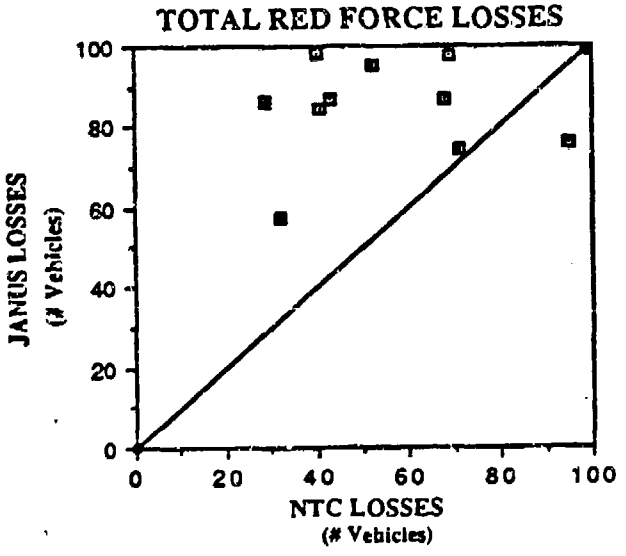


FIGURE 7. Scatter Plot of the Total Red Force Losses.

This dispersion indicates that the number of red force kills experienced were much more variable than the blue force kills and thus the correlation for the red force losses between the NTC and JANUS (T) data is weaker.

The most significant result of the scatter plot analysis was the information on the survivability and lethality of the blue force TOWs at the NTC in comparison to JANUS (T). Figures 8 ,9,10 and 11 show the comparisons involving the blue force TOWs with the red tanks and BMPs.

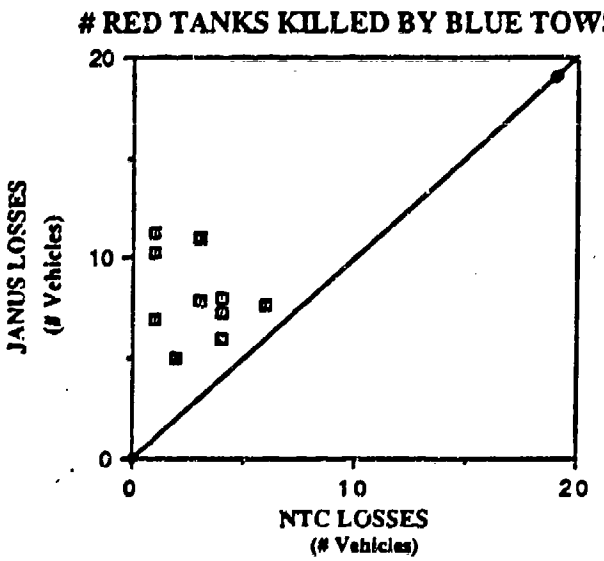


FIGURE 8. Scatter Plot of the Total Red Force Tank Losses to Blue Force TOWs.

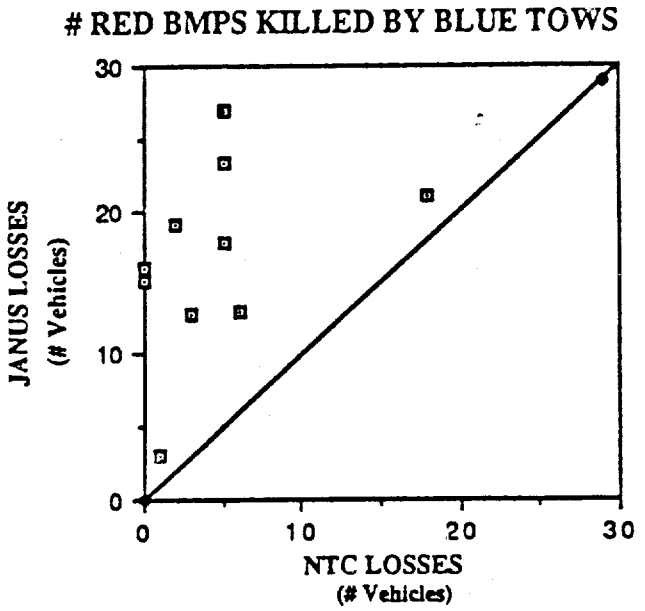


FIGURE 9. Scatter Plot of the Total Red Force BMP Losses to Blue Force TOWs.

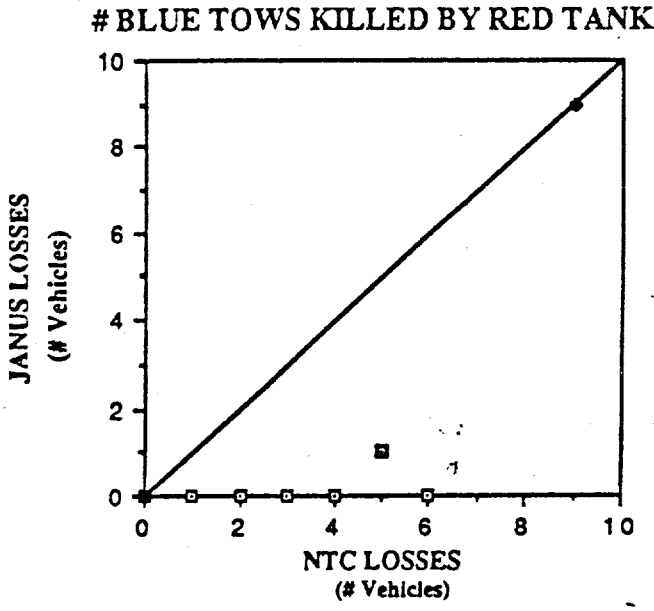


FIGURE 10. Scatter Plot of the Number of Blue Force TOW Losses to the Red Force Tanks.

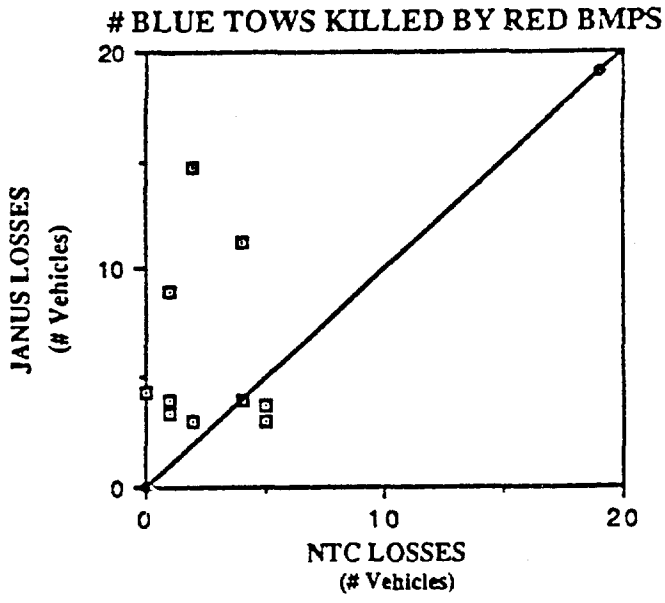


FIGURE 11. Scatter Plot of the Number of Blue Force TOW Losses to Red Force BMPs.

The comparison of the number of red TANKS killed by blue TOWs (Figure 8) show the plotted points grouped in the upper left of the graph. This implies that the number of red TANKS lost in JANUS (T) to the blue TOWs were significantly higher than were experienced at the NTC. The same analysis of the number of red BMPs killed by blue TOWs (Figure 9) show a similar result. However, a plot of the number of blue TOWs killed by red tanks (Figure 10) shows that only one blue TOW was lost to a red tank in all ten JANUS (T) battles, while the plot of blue TOW losses by red BMPs (Figure 11) shows that blue TOWs experienced more losses in the JANUS (T) model than at NTC. Thus the conclusion can be made that the blue TOWs, as an individual

weapon system, are significantly more lethal against the red force and better able to survive the battle against red tanks, but die more frequently at the hands of red BMPs in the JANUS (T) model than at the NTC.

The same result can be derived for the red BMPs versus the blue tanks. Figure 12 shows that the number of blue tanks killed by red BMPs is significantly higher in the JANUS (T) model than for the NTC, indicated by the plotted points being in the upper left portion of the graph. At the same time, Figure 13 shows the plotted points for the number of red BMPs lost to blue tanks is well below the line Y=X. Therefore the red BMPs are surviving better against the blue tanks and at the same time are more lethal.

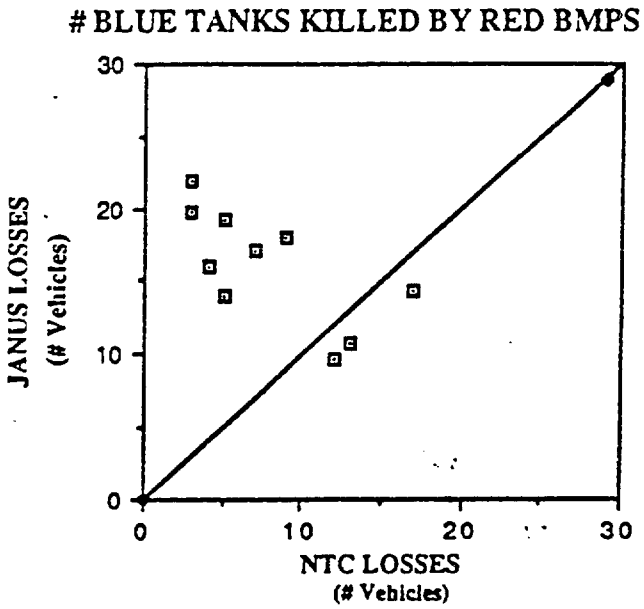


FIGURE 12. Scatter Plot of the Number of Blue Force Tank Losses to the Red Force BMPs.

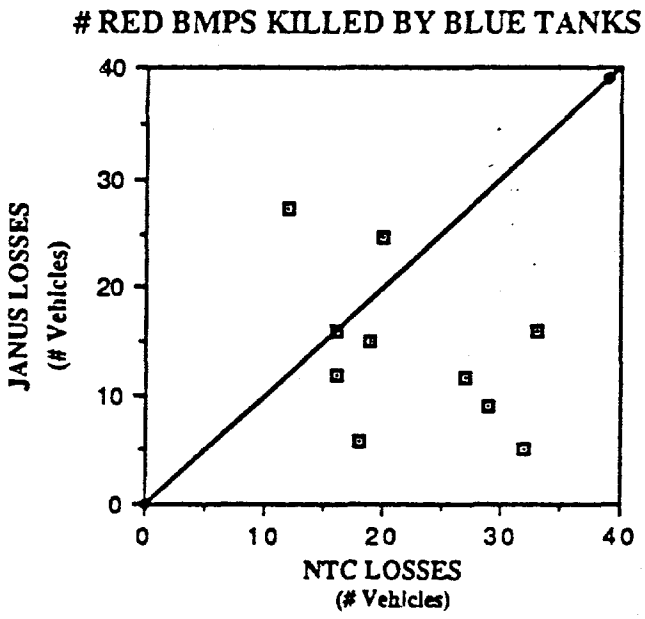


FIGURE 13. Scatter Plot of the Number of Red Force BMPs Losses to the Blue Force Tanks.

The other scatter plots show the plotted data to be positioned in the upper center portion of the graphs which indicates a general trend of more JANUS (T) kills than NTC. Figure 14 shows this trend for the total number of red tank losses. However, no other significant differences exist between weapon system types from which one may draw the strong conclusion for other weapon systems as for the blue TOWs and BMPs.

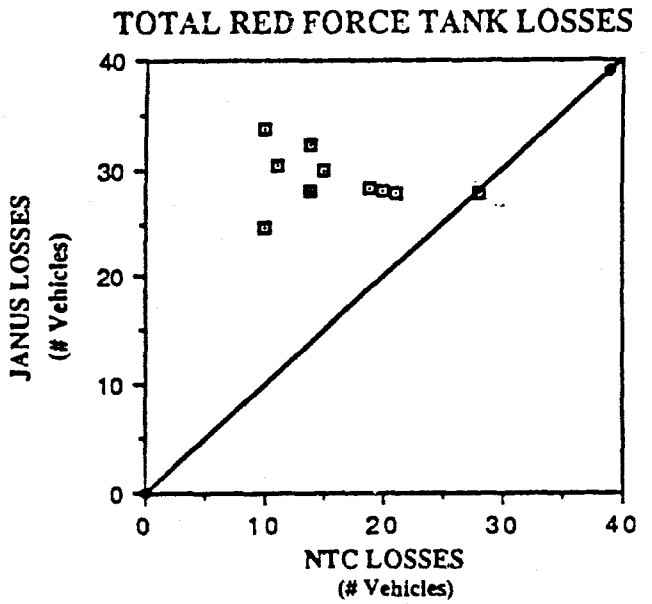


FIGURE 14. Scatter Plot of the Total Red Force Tank Losses.

F. REGRESSION AS A COMPARISON TOOL

For a particular weapon system, (e. g. red tanks) there are two records of numbers killed. Let Y be the JANUS (T) result and X be the NTC result. If Y=X for all ten battles, the results of JANUS (T) and the NTC are in perfect agreement; however this does not occur. least squares regression was used to investigate the relationship. Analysis using the regression technique was accomplished by relating the terms 'accuracy' and 'consistency' of agreement to the regression results. These terms are defined as follows:

Consistency - the scatter of the data points about the least squares fitted line.

Accuracy - the estimated slope coefficient's closeness to 1.
[Ref. 8:p. 32]

The investigation of the consistency of agreement between the results observed at the NTC and those observed in the JANUS (T) model consisted of using the scatter plot and simple regression techniques. Consistency of agreement between the two sources would be assessed based on the scatter of the plotted points about the least squares regression line. If all the plotted data points lie on the fitted line, the NTC and JANUS (T) data would be considered consistent. The greater the scatter of the plotted points about the fitted line, the less the consistency of agreement between the two sources.

The examination of the accuracy of agreement is predicated upon having an acceptable consistency assessment. The investigation of accuracy between the two data sources requires only the technique of regression for calculation of the y intercept and slope coefficients of the least squares fitted line. Accuracy is determined by the nearness of the estimated slope coefficient to the value 1. For example, a regression slope coefficient of 1 and y intercept of 0 would imply the data lay on the line Y = X, indicating absolute agreement between the observations from the NTC and JANUS

(T) model. Additionally, a regression slope of 1 and a y intercept of a positive or negative constant would also indicate agreement between the sources with a correction factor equal to the y intercept.

G. REGRESSION ANALYSIS: MODEL $Y = \alpha + \beta X + \varepsilon$

The scatter plots and associated least squares regression lines for the seventeen comparison categories used in the scatter plot analysis are shown in Appendix H. The corresponding consistency and accuracy assessments are displayed in Table 12.

These graphs show fair to good consistency of agreement for six (1,2,3,4,5,11) of the seventeen comparisons (see examples, comparison # 1,total blue kills and comparison # 2, blue tank losses in Figures 15 and 16).

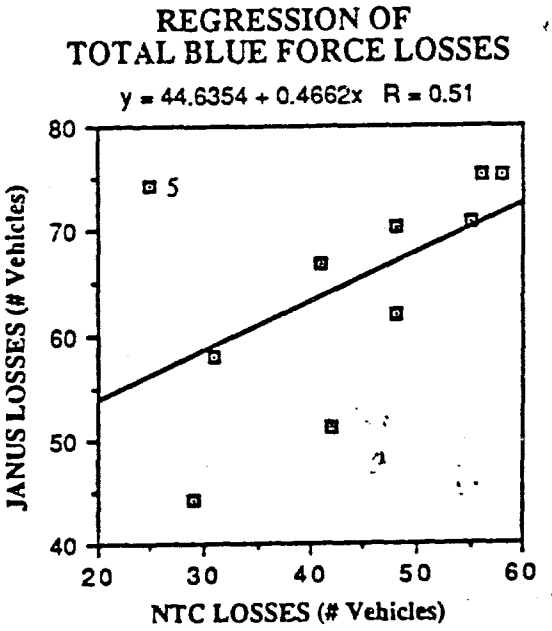


FIGURE 15. Regression of the Total Blue Force Losses.

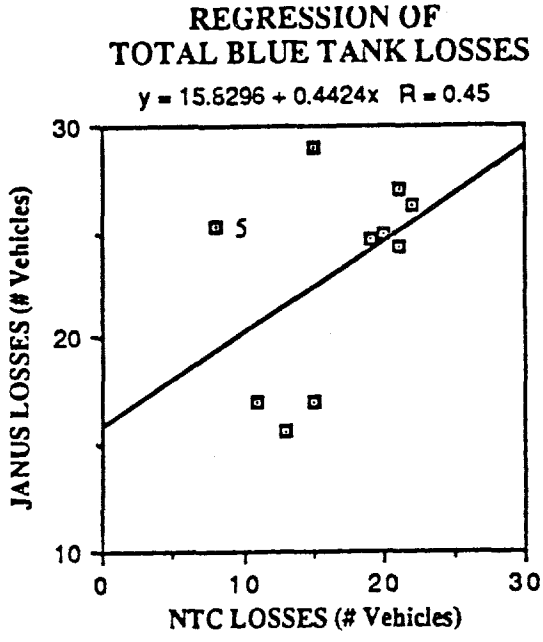


FIGURE 16. Regression of the Total Blue Tanks Losses.

It should be noted that in the six cases of acceptable consistency all are comparisons dealing with blue force weapon system losses. In all other cases significant variability of the data points about the fitted line is displayed. The comparisons dealing with the red forces are particular poor.

TABLE 12

CONSISTENCY AND ACCURACY ASSESSMENTS ON REGRESSION LINES

COMPARISON NUMBER	CONSISTENCY ASSESSMENT	SLOPE VALUE	ACCURACY ASSESSMENT
1	GOOD	0.446	FAIR
2	GOOD	0.442	FAIR
3	FAIR	0.531	FAIR
4	FAIR	0.155	FAIR
5	GOOD	0.601	FAIR
6	POOR	0.005	N/A
7	POOR	-0.143	N/A
8	POOR	0.014	N/A
9	POOR	-0.032	N/A
10	POOR	-0.259	N/A
11	FAIR	0.456	FAIR
12	POOR	-0.388	N/A
13	POOR	0.043	N/A
14	POOR	-0.483	N/A
15	POOR	-0.596	N/A
16	POOR	0.488	N/A
17	POOR	-0.143	N/A

Of the six comparisons which show acceptable consistency, there still seems to be a couple of outlier points on each graph which pull the least squares line away from what looks to be the primary grouping of data with slope of approximately 1. The next step, therefore, was to identify these outlier points on the graphs for the six blue force comparisons showing the possibility of a relationship. This analysis yielded the results that one outlier point for four of the six corresponded to the same battle. The number of losses experienced by the blue force at the NTC for this battle was on the low end of the distribution of the ten NTC

observations. On the other hand the number of kills observed in the JANUS (T) model of the same battle was markedly higher. Table 13 shows the total number of blue losses arranged by the order statistics of the NTC values with the corresponding battle number and JANUS (T) losses.

TABLE 13

TOTAL BLUE LOSSES

BATTLE #	5	3	1	6	2	4	9	10	8	7
# NTC	25	31	33	41	42	48	55	56	58	58
# JANUS	70.3	58	44.3	60	50.3	70.3	70.7	77	76.7	62

From this table the fifth battle had a lower number of blue force losses while the JANUS (T) model yielded a significantly higher result. Battle number five was found to also be an outlier in comparisons 2,4 and 5. This implies that the plotted point is within the normal range of the JANUS (T) values but falls on the low end of the distribution of NTC values. Therefore, this point was omitted and the regression model was applied to the six comparisons again. Figures 17 and 18 show the revised regression line for the total blue force losses and blue tank losses, respectively.

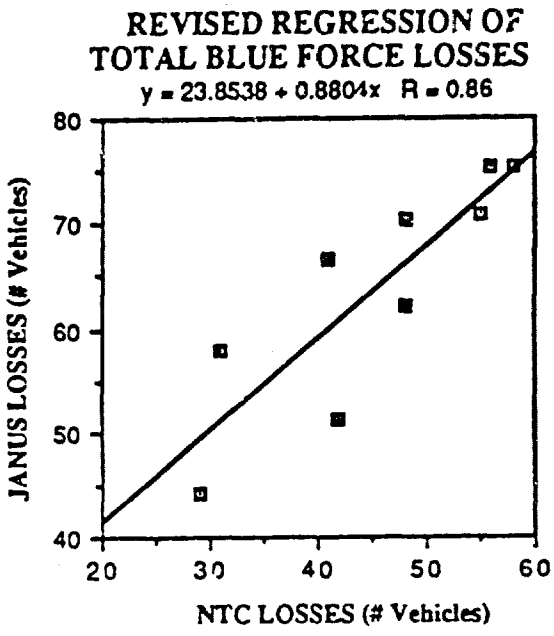


FIGURE 17. Revised Regression of the Total Blue Losses.

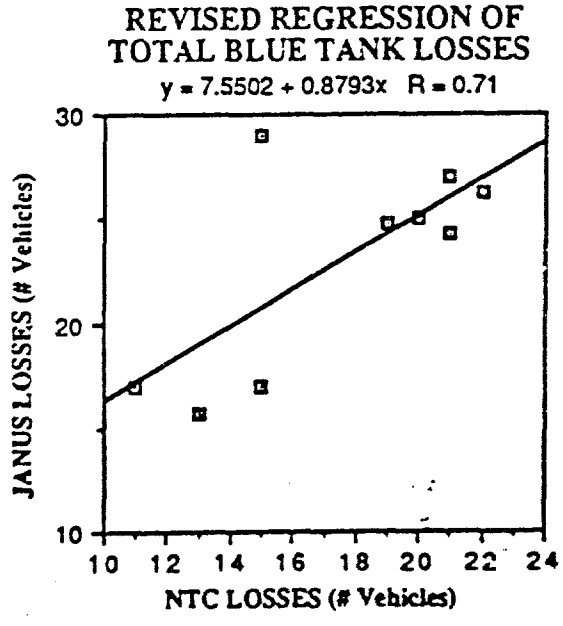


FIGURE 18. Revised Regression of the Total Blue Tank Losses.

The other revised scatter plots and associated least squares lines are shown in Appendix I. The consistency and agreement assessments are displayed in Table 14.

TABLE 14

REVISED CONSISTENCY AND ACCURACY ASSESSMENTS

COMPARISON NUMBER	CONSISTENCY ASSESSMENT	SLOPE VALUE	ACCURACY ASSESSMENT
1	GOOD	0.880	GOOD
2	GOOD	0.879	GOOD
3	GOOD	0.571	FAIR
4	FAIR	0.272	POOR
5	GOOD	0.690	FAIR
11	FAIR	0.448	POOR

The consistency and accuracy of agreement between the NTC results and JANUS (T) results for the four of the six comparisons (1,2,3,11) which had been considered as possibly having a relationship was confirmed. The tightness of the plotted points about the fitted line and the closeness of the slope to the value 1 indicate that the JANUS (T) combat model yielded the same results as were experienced by the rotational units at the NTC. However, the data show that no relation can be inferred between the number of red force kills observed in the model and those experienced at the NTC.

The reason for the consistency and accuracy of agreement for the blue force is that the red force

outnumbers the blue force by such a large margin that all the blue forces in the path of the three motorized rifle battalions are destroyed in both the model and at the NTC. The blue force weapon systems may not be killed at the same time of the battle or by the same red force weapon type, but if they are in the red force path they are eventually killed. On the other hand, the number of red kills seems to vary widely and possibly is dependent on factors such as unit training proficiency and quality of leadership in the blue force, elements of warfare which are difficult to quantify.

The final conclusion for the regression analysis is that the losses experienced by the blue forces in both JANUS (T) and the NTC are consistent and accurate, but the wide differences between the results of the two sources for the red force indicate no consistency or accuracy of agreement.

H. EXAMINATION OF THE DIFFERENCE IN LOSSES FOR THE NTC AND JANUS (T) COMBAT MODEL

The final comparison is an examination of the difference between the observed losses in the JANUS (T) model and the observed losses at the NTC for each battle. Each observation in the NTC is paired with the average of three runs of the JANUS (T) model using the same force structure. The difference of the two observations is

computed by subtracting the NTC result from the JANUS (T) result. If the distribution of the NTC data is the same as the JANUS (T) data the difference should be zero. Thus by using a t statistic one can determine the number of standard deviations the sample mean is away from the theoretical value of zero. The greater the number of standard deviations away from the value of zero the greater the evidence that the two samples do not come from the same distribution. Additionally, if the two distributions are not the same the sign of the average indicates the direction of the difference between the two samples. For example, if the average is positive, the JANUS (T) results are higher than the NTC and if the average is negative, the NTC results are larger than JANUS. The t statistic is computed as follows:

$$t = XBAR \div SD_{XBAR}$$

where:

XBAR = average of the differences between the paired observations

SD_{XBAR} = the standard deviation of the average of the differences of the paired observations

This procedure was applied to the seventeen categories of comparison. An example for comparison number 8, total red force BMP losses, is shown in Table 15.

TABLE 15

TOTAL RED BMPs KILLED

JANUS	NTC	JANUS - NTC
42.3	13	29.3
28.7	19	9.7
39.0	44	-5.0
51.0	24	27.0
42.0	25	17.0
41.0	29	12.0
47.0	26	21.0
53.0	43	10.0
47.0	37	10.0
34.7	54	-19.3
AVG DIFF		11.17
VAR XBAR		21.17
SQRT VAR XBAR		4.60
T STATISTIC		2.42

For this example, the mean difference is 11.17 with a standard deviation of 4.60. The resulting t statistic is 2.42, which implies that the sample mean is 2.42 standard deviations away from the theoretical value of zero. 2.42 standard deviations away from the theoretical value of zero implies that the assumption that the distribution of the two sources is the same might be in error. This comparison method also indicates that the JANUS (T) results are larger than the NTC because the difference between JANUS (T) and

NTC data is a positive number. This result is consistent with previous findings. The computed averages of the differences, standard deviations of the averages and associated t statistic are shown in Table 16 for the seventeen comparison categories. In only two of the seventeen categories are the average differences close to zero (3 and 11), and in two other cases (13 and 14) the average differences are negative. Comparison number three is total blue TOW losses. In this case the computed t statistic was 0.65. This implies that the average difference is approximately zero. However, this comes from the large positive and negative differences for each battle which were displayed in the scatter plot in Figure 6. This is not the desired result to confirm the hypothesis that the distributions are the same. Therefore preference is given to the previous conclusion that the distributions are not the same. Comparison number 11 is the number of blue tanks killed by red tanks. The computed differences between the two sources are all small numbers very close to zero. This implies that the NTC and JANUS(T) results for these comparisons are very similar for all battles and the distributions could be the same. This is also consistent with the previous findings from the scatter plot and regression analysis.

There are two categories of comparison which resulted in negative average numbers; the number of blue TOWs killed by red tanks and the number of red BMPs killed by blue tanks. This implies that the number of losses at the NTC was higher than the observed number of losses in the JANUS (T) model. Again, this result is consistent with previous findings of the scatter plot analysis for these comparisons.

TABLE 16

RESULTS OF THE DIFFERENCE COMPARISON

BATTLE NUMBER	AVERAGE OF DIFFERENCES	STD DEV OF AVG	T STATISTIC
1.	21.52	3.53	6.10
2.	6.63	1.58	4.18
3.	0.77	1.19	0.65
4.	8.19	2.25	3.63
5.	11.41	1.77	6.43
6.	30.33	7.70	3.94
7.	12.97	2.16	6.01
8.	11.17	4.60	2.43
9.	24.14	6.59	3.66
10.	4.54	1.99	2.28
11.	0.19	1.02	0.19
12.	5.43	0.97	5.57
13.	-2.60	0.75	-3.74
14.	-7.96	4.02	-1.98
15.	8.27	2.55	3.25
16.	12.27	2.11	5.81
17.	3.53	1.47	2.41

I. SUMMARY

The results of the analysis are as follows:

1. The losses experienced in the JANUS (T) combat model are higher than those observed at the NTC at both the aggregate and individual weapon system comparison level. Although the end of battle data do not contain the information as to why this happens, it is the author's opinion that JANUS (T) is possibly overly optimistic in its detection subroutines. This means that the detection queue for each weapon system is constantly backed up with detections of the opposing force which then allows the firing weapon system to literally shoot until it runs out of ammunition, runs out of targets at which to shoot, or is killed itself.

2. The JANUS (T) and NTC battle results for the blue force comparisons show a battle for battle correlation in the number of weapon systems lost. This results because the blue force in both the model and at the NTC is defeated by the overwhelming numbers of the red force and all blue force weapon systems in the path of the red force eventually become casualties.

3. The lethality and survivability of the blue force TOW and red BMP weapon systems are significantly higher in the JANUS (T) model than at the NTC. These differences are caused by the JANUS (T) model taking advantage of the full range of the weapon systems, whereas this does not always occur at the NTC.

VI. RESULTS, CONCLUSIONS AND RECOMMENDATIONS

A. RESULTS AND CONCLUSIONS

The intent of this thesis was to compare the direct fire killer/victim data resulting from the ten defend in sector battles which occurred at the Siberia location of the National Training Center with the killer/victim data generated by playing the Siberia defend in sector scenario developed from the position/location data tapes of the ten battles in the JANUS (T) combat model. The comparison was based on an analysis of the losses experienced by both sides on both the aggregate and individual weapon system level.

The results and conclusions of this research are as follows:

1. The aggregated analysis showed that the JANUS (T) combat model results in a greater number of losses for both the red and blue forces than are observed at the National Training Center. A possible cause for the greater number of kills in the JANUS (T) model is the detection subroutine. The detection subroutine might be overly optimistic in that it allows each vehicle to keep a continuous list of enemy vehicles detected in a queue. Thus each vehicle has a continuous list of targets at which to shoot and is only limited by the amount of ammunition it carries in its basic load. The end result is that each vehicle on both sides fires continuously until it runs out of ammunition or is itself killed.

2. The regression of the aggregated weapon system losses showed the number of kills observed at the NTC and the number of kills observed in the JANUS (T) model to be highly correlated for the blue force. This finding is attributed to the fact that in both the JANUS (T) model and the NTC, the red force outnumbers the blue force by such a large margin (3 to 1 in tank killing weapon systems) that regardless of the blue force capability they are so outnumbered that they are eventually overwhelmed by the red force. Since the red route of attack is the same for each battle, all blue force vehicles in this path, in both JANUS (T) and at the NTC, become casualties. Thus the correlation is due to the fact that the red force wins in both JANUS (T) and at the NTC and does so by inflicting approximately the same number of casualties.

3. The analysis of the individual weapon systems showed that the red force BMP and blue force TOW inflict more casualties in the JANUS (T) model than were observed at the NTC.

   a. The blue force TOWs were attributed with almost three times the casualties in the JANUS (T) model than were observed at the NTC. The blue force TOW is a wire guided anti-tank missile platform. It is capable of destroying armored vehicles out to a range of 3750 meters with deadly accuracy. This capability of the TOW is maximized in the JANUS (T) model as evidenced by the fact that more than 90% of the casualties caused by the blue force TOW occurred at distances of more than 3000 meters. Complete data from the NTC to compare at what range the TOW engages are not available with the current state of instrumentation, but it is the general opinion of the personnel at the NTC that the blue force TOW is not being used to its fullest capability. Therefore the large difference can possibly be attributed to both the model and the performance of the TOW crews at the NTC.

   b. The red force BMPs were attributed with almost twice the number of kills in the JANUS (T) model as were observed at the NTC. Like the TOW the BMP is also a wire guided anti-tank missile platform. It is capable of causing casualties out to 3000 meters. This attribute is the reason for the

greater number of blue tanks killed by the red BMPs. The blue tanks' maximum range is about 2250 meters. Since the red force attacks with the red tanks in the lead, followed by the red BMPs, the blue tanks engage the red tanks first at ranges around 2000 meters, giving away their defensive position. Thus the red BMPs can begin inflicting casualties on the blue tanks before they come into range of the blue tanks. Additionally there was a large difference in the number of blue force APCs killed in the JANUS (T) model compared to the NTC. This is caused by the fact that at the NTC, blue APCs do not engage the red BMPs because the probability of causing a casualty is very low and engagement only means death. In the JANUS (T) model this discretion is apparently not played and the APCs attempt to kill the BMPs whenever they are within range of the 50 caliber machine gun. The probability of kill is still low so the APC gives his position away and dies quickly by the anti-tank missile or the 73mm smooth bore cannon.

4. In partial response to the GAO finding that the data being captured at the NTC were being underutilized, the NTC killer/victim data base was augmented with the necessary categorization data to make accurate trend line analysis possible. This data base was instrumental in the identification of the Siberia location as being the most promising for developing the defend in sector scenario used in this thesis.

B. RECOMMENDATIONS

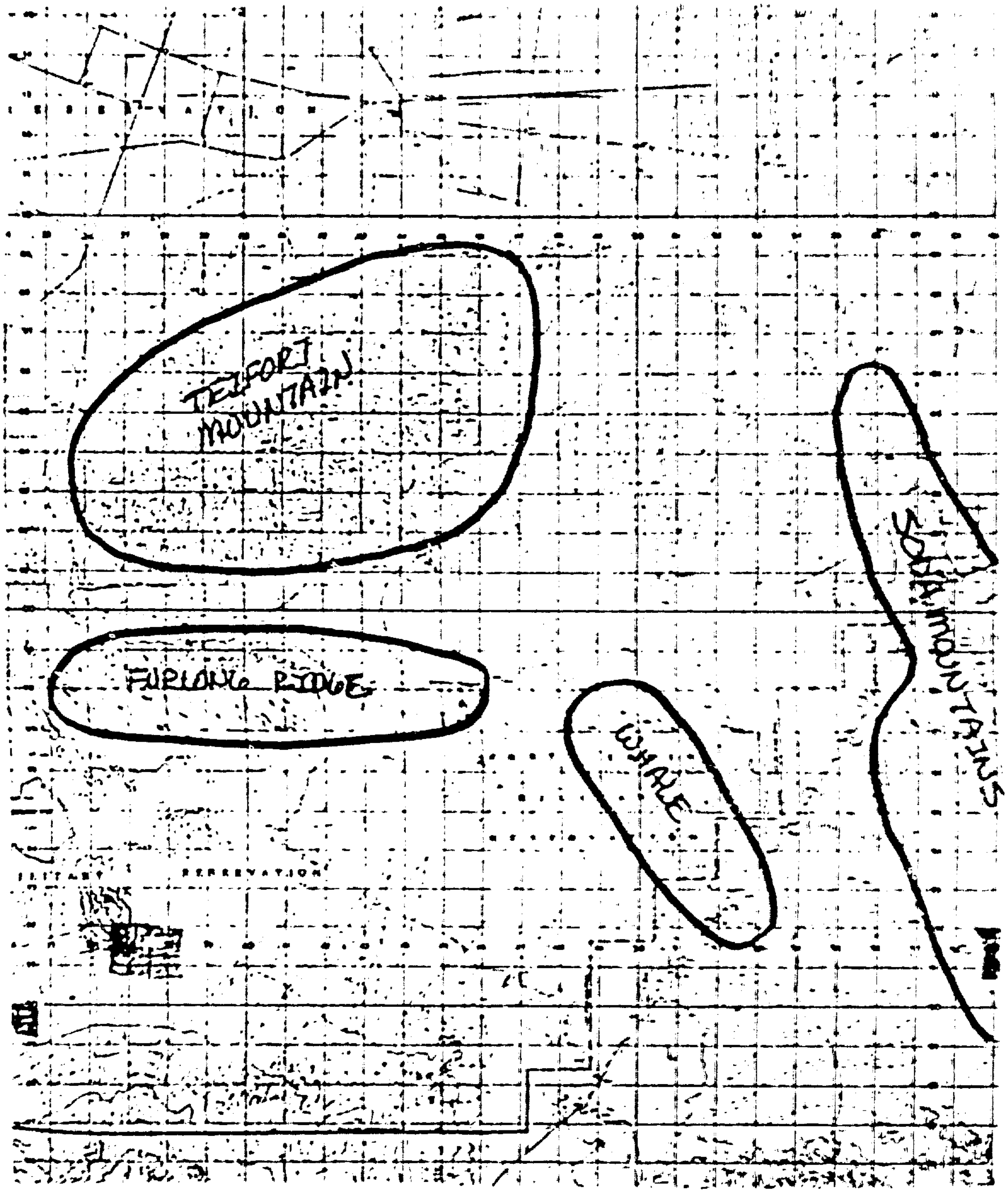
Continuing research should be conducted in the comparison of the NTC results with the JANUS (T) model. Every rotation at the NTC results in more battles being conducted at the Siberia location. With this additional information the developed defend in sector scenario can be improved and a larger sample size might provide additional information which was masked by the small sample size used

in this thesis. Additionally, further research could lead to development of the necessary parameters in the JANUS (T) model which would replicate the trend line NTC result. Then the JANUS (T) model could be used by battalion operations officers to test different strategies prior to their deployment to the NTC. Finally, it is recommended that the NTC data base continue to be updated with the categorical data so that it can be used for further analysis and research.

APPENDIX A

MAP OF THE SIBERIA LOCATION OF THE NTC

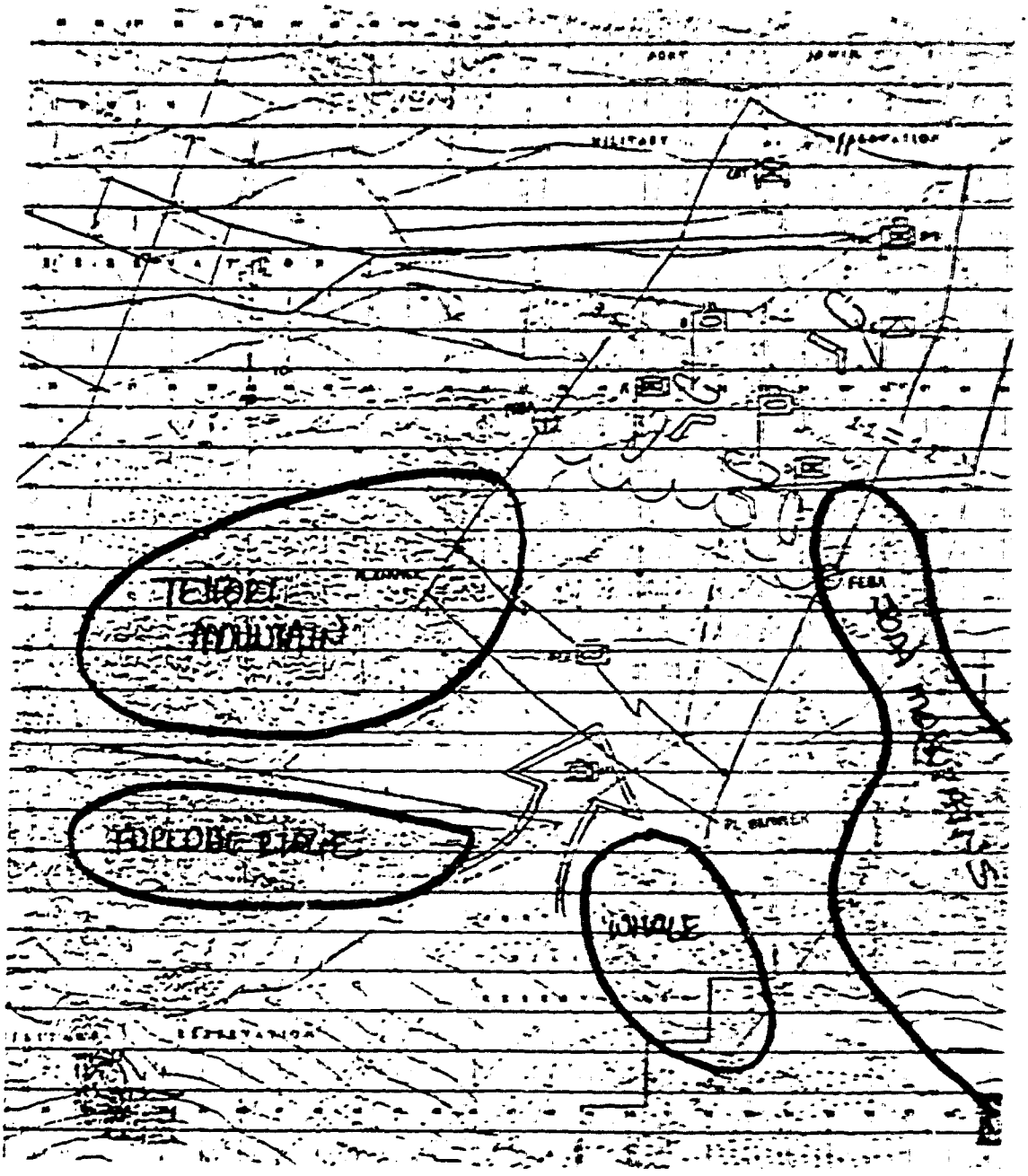
Appendix A contains a map of the Siberia location of the National Training Center. The major terrain features are annotated with their assigned name.


TELFORT MOUNTAIN
FURLONG RIDGE
WHALE
SODA MOUNTAINS

APPENDIX B

BLUE DEFENSIVE POSITIONS AND RED ROUTE OF ATTACK

Appendix B also contains a map of the Siberia location of the National Training Center; however graphics of the blue force defensive positions are shown for the generic defend in sector scenario developed in Chapter III. Additionally, the red force route of attack is shown. It is easy to see that the terrain features force the red force route of attack to be nearly the same for each battle.



APPENDIX C

RED AND BLUE LOSSES BY BATTLE

Appendix C contains the data used in this thesis for the total number of weapon systems of both the red and blue forces which were lost by battle number. The recorded losses for all three runs of the JANUS (T) model of each battle are shown along with the corresponding losses for the National Training Center.

BATTLE NUMBER 1

RED VICTIM DATA

RED WEAPON SYSTEM	RED START	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	RED NTC LOSSES	RATIO JANUS TO NTC
TANK	40	33	34	34	33.67	10	3.37
BMP	72	42	42	43	42.33	13	3.26
BRDM	2	0	0	1	0.33	1	0.33
SP122	4	1	1	1	1.00	1	1.00
MTLB	7	7	7	7	7.00	2	3.50
ZSU	2	2	2	2	2.00	2	1.00
HIND	0	0	0	0	0.00	0	0.00
TOTAL	127	85	86	88	86.33	29	2.98

BLUE VICTIM DATA

BLUE WEAPON SYSTEM	BLUE START	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	BLUE NTC LOSSES	RATIO JANUS TO NTC
TANK	22	15	17	15	15.67	13	1.21
APC	31	18	18	18	18.00	5	3.60
TOW	7	4	4	4	4.00	4	1.00
MORTAR	5	0	0	0	0.00	3	0.00
VULCAN	4	1	1	1	1.00	3	0.33
COBRA	6	6	5	6	5.67	1	5.67
TOTAL	75	44	45	44	44.33	29	1.53

BATTLE NUMBER 2

RED VICTIM DATA

RED WEAPON SYSTEM	RED START	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	RED NTC LOSSES	RATIO JANUS TO NTC
TANK	40	25	25	24	24.67	10	2.47
BMP	94	31	30	25	28.67	19	1.51
BRDM	3	0	0	0	0.00	0	0.00
SP122	5	0	0	0	0.00	1	0.00
MTLB	15	3	4	0	2.33	0	0.00
ZSU	2	0	0	0	0.00	1	0.00
HIND	2	2	2	2	2.00	1	2.00
TOTAL	161	61	61	51	57.67	32	1.80

BLUE VICTIM DATA

BLUE WEAPON SYSTEM	BLUE START	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	BLUE NTC LOSSES	RATIO JANUS TO NTC
TANK	27	27	26	27	26.67	22	1.21
APC	32	19	16	19	18.00	14	1.29
TOW	7	5	3	6	4.67	6	0.78
MORTAR	6	0	0	0	0.00	0	0.00
VULCAN	3	1	1	1	1.00	0	0.00
COBRA	1	1	1	1	1.00	0	0.00
TOTAL	76	53	47	54	51.33	42	1.22

BATTLE NUMBER 3

RED VICTIM DATA

RED WEAPON SYSTEM	RED START	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	RED NTC LOSSES	RATIO JANUS TO NTC
TANK	40	28	27	28	27.67	21	1.32
BMP	94	41	36	40	39.00	44	0.89
BRDM	4	0	0	0	0.00	1	0.00
SP122	7	0	0	0	0.00	5	0.00
MTLB	18	5	5	7	5.67	0	0.00
ZSU	3	2	2	2	2.00	0	0.00
HIND	4	0	0	0	0.00	0	0.00
TOTAL	170	76	70	77	74.33	71	1.05

BLUE VICTIM DATA

BLUE WEAPON SYSTEM	BLUE START	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	BLUE NTC LOSSES	RATIO JANUS TO NTC
TANK	29	29	29	29	29.00	15	1.93
APC	43	23	24	25	24.00	14	1.71
TOW	8	4	4	4	4.00	2	2.00
MORTAR	0	0	0	0	0.00	0	0.00
VULCAN	4	1	1	1	1.00	0	0.00
COBRA	0	0	0	0	0.00	0	0.00
TOTAL	84	57	58	59	58.00	31	1.87

BATTLE NUMBER 4

RED VICTIM DATA

RED WEAPON SYSTEM	RED START	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	RED NTC LOSSES	RATIO JANUS TO NTC
TANK	40	33	32	32	32.33	14	2.31
BMP	97	49	52	52	51.00	24	2.13
BRDM	3	0	0	0	0.00	1	0.00
SP122	6	2	4	4	3.33	0	0.00
MTLB	11	11	10	10	10.33	0	0.00
ZSU	3	2	1	1	1.33	1	1.33
HIND	3	0	0	0	0.00	0	0.00
TOTAL	163	97	99	99	98.33	40	2.46

BLUE VICTIM DATA

BLUE WEAPON SYSTEM	BLUE START	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	BLUE NTC LOSSES	RATIO JANUS TO NTC
TANK	26	24	25	25	24.67	19	1.30
APC	65	31	28	28	29.00	13	2.23
TOW	12	3	4	4	3.67	9	0.41
MORTAR	5	0	0	0	0.00	0	0.00
VULCAN	4	1	1	1	1.00	3	0.33
COBRA	12	12	12	12	12.00	4	3.00
TOTAL	124	71	70	70	70.33	48	1.47

BATTLE NUMBER 5

RED VICTIM DATA

RED WEAPON SYSTEM	RED START	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	RED NTC LOSSES	RATIO JANUS TO NTC
TANK	40	28	28	28	28.00	14	2.00
BMP	102	46	40	40	42.00	25	1.68
BRDM	4	0	0	0	0.00	0	0.00
SP122	8	4	3	3	3.33	0	0.00
MTLB	8	5	5	5	5.00	1	5.00
ZSU	3	2	2	2	2.00	1	2.00
HIND	4	4	4	4	4.00	0	0.00
TOTAL	169	89	82	82	84.33	41	2.06

BLUE VICTIM DATA

BLUE WEAPON SYSTEM	BLUE START	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	BLUE NTC LOSSES	RATIO JANUS TO NTC
TANK	26	26	25	25	25.33	8	3.17
APC	56	33	37	37	35.67	13	2.74
TOW	14	6	5	5	5.33	2	2.67
MORTAR	6	0	0	0	0.00	0	0.00
VULCAN	4	1	1	1	1.00	0	0.00
COBRA	7	7	7	7	7.00	2	3.50
TOTAL	113	73	75	75	74.33	25	2.97

BATTLE NUMBER 6

RED VICTIM DATA

RED WEAPON SYSTEM	RED START	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	RED NTC LOSSES	RATIO JANUS TO NTC
TANK	40	30	30	31	30.33	11	2.76
BMP	91	41	41	41	41.00	29	1.41
BRDM	5	0	0	0	0.00	2	0.00
SP122	0	0	0	0	0.00	0	0.00
MTLB	13	8	8	9	8.33	0	0.00
ZSU	3	3	3	3	3.00	0	0.00
HIND	4	4	4	4	4.00	1	4.00
TOTAL	156	86	86	88	86.67	43	2.02

BLUE VICTIM DATA

BLUE WEAPON SYSTEM	BLUE START	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	BLUE NTC LOSSES	RATIO JANUS TO NTC
TANK	22	17	27	27	23.67	15	1.58
APC	56	29	29	29	29.00	20	1.45
TOW	14	9	9	9	9.00	2	4.50
MORTAR	6	0	0	0	0.00	3	0.00
VULCAN	2	0	0	0	0.00	1	0.00
COBRA	5	5	5	5	5.00	0	0.00
TOTAL	105	60	70	70	66.67	41	1.63

BATTLE NUMBER 7

RED VICTIM DATA

RED WEAPON SYSTEM	RED START	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	RED NTC LOSSES	RATIO JANUS TO NTC
TANK	40	30	30	30	30.00	15	2.00
BMP	98	47	47	47	47.00	26	1.81
BRDM	4	0	0	0	0.00	2	0.00
SP122	6	0	0	0	0.00	4	0.00
MTLB	13	9	9	9	9.00	1	9.00
ZSU	4	3	3	3	3.00	3	1.00
HIND	6	6	6	6	6.00	1	6.00
TOTAL	171	95	95	95	95.00	52	1.83

BLUE VICTIM DATA

BLUE WEAPON SYSTEM	BLUE START	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	BLUE NTC LOSSES	RATIO JANUS TO NTC
TANK	28	27	27	27	27.00	21	1.29
APC	59	29	29	29	29.00	19	1.53
TOW	9	4	4	4	4.00	4	1.00
MORTAR	6	1	1	1	1.00	1	1.00
VULCAN	4	1	1	1	1.00	3	0.33
COBRA	0	0	0	0	0.00	0	0.00
TOTAL	106	62	62	62	62.00	48	1.29

BATTLE NUMBER 8

RED VICTIM DATA

RED WEAPON SYSTEM	RED START	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	RED NTC LOSSES	RATIO JANUS TO NTC
TANK	39	28	29	28	28.33	19	1.49
BMP	96	51	52	56	53.00	43	1.23
BRDM	4	0	0	0	0.00	2	0.00
SP122	6	1	1	1	1.00	1	1.00
MTLB	12	9	7	7	7.67	0	0.00
ZSU	4	4	3	4	3.67	2	1.83
HIND	4	4	4	4	4.00	2	2.00
TOTAL	165	97	96	100	97.67	69	1.42

BLUE VICTIM DATA

BLUE WEAPON SYSTEM	BLUE START	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	BLUE NTC LOSSES	RATIO JANUS TO NTC
TANK	26	25	25	25	25.00	21	1.19
APC	50	30	28	29	29.00	13	2.23
TOW	17	11	13	10	11.33	10	1.13
MORTAR	6	0	0	0	0.00	6	0.00
VULCAN	3	1	1	1	1.00	3	0.33
COBRA	9	9	9	9	9.00	5	1.80
TOTAL	111	76	76	74	75.33	58	1.30

BATTLE NUMBER 9

RED VICTIM DATA

RED WEAPON SYSTEM	RED START	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	RED NTC LOSSES	RATIO JANUS TO NTC
TANK	40	28	28	28	28.00	20	1.40
BMP	101	47	47	47	47.00	37	1.27
BRDM	5	0	0	0	0.00	3	0.00
SP122	5	0	0	0	0.00	1	0.00
MTLB	11	6	6	6	6.00	5	1.20
ZSU	3	2	2	2	2.00	1	2.00
HIND	4	4	4	4	4.00	1	4.00
TOTAL	169	87	87	87	87.00	68	1.28

BLUE VICTIM DATA

BLUE WEAPON SYSTEM	BLUE START	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	BLUE NTC LOSSES	RATIO JANUS TO NTC
TANK	26	25	25	25	25.00	20	1.25
APC	54	32	33	33	32.67	27	1.21
TOW	15	4	4	4	4.00	8	0.50
MORTAR	5	0	0	0	0.00	0	0.00
VULCAN	5	2	2	2	2.00	0	0.00
COBRA	7	7	7	7	7.00	0	0.00
TOTAL	112	70	71	71	70.67	55	1.28

BATTLE NUMBER 10

RED VICTIM DATA

RED WEAPON SYSTEM	RED START	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	RED NTC LOSSES	RATIO JANUS TO NTC
TANK	40	28	29	29	28.67	28	1.02
BMP	102	42	31	31	34.67	54	0.64
BRDM	4	0	0	0	0.00	0	0.00
SP122	6	1	1	1	1.00	4	0.25
MTLB	20	4	6	6	5.33	6	0.89
ZSU	3	3	2	2	2.33	3	0.78
HIND	4	4	4	4	4.00	0	0.00
TOTAL	179	82	73	73	76.00	95	0.80

BLUE VICTIM DATA

BLUE WEAPON SYSTEM	BLUE START	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	BLUE NTC LOSSES	RATIO JANUS TO NTC
TANK	20	17	17	17	17.00	11	1.55
APC	66	40	35	35	36.67	29	1.26
TOW	18	14	15	15	14.67	10	1.47
MORTAR	5	0	0	0	0.00	3	0.00
VULCAN	6	2	2	2	2.00	3	0.67
COBRA	5	5	5	5	5.00	0	0.00
TOTAL	120	78	74	74	75.33	56	1.35

APPENDIX D

RED AND BLUE LOSSES BY WEAPON SYSTEM

Appendix D contains the data used in this thesis for the total number of losses, by weapon system type for each of the ten battles.

NUMBER OF BLUE TANKS KILLED

BATTLE NUMBER	NTC LOSSES	JANUS LOSSES	RATIO
1	13.00	15.67	1.21
2	14.00	18.00	1.29
3	15.00	29.00	1.93
4	19.00	24.67	1.30
5	8.00	25.33	3.17
6	15.00	23.67	1.58
7	21.00	27.00	1.29
8	21.00	25.00	1.19
9	20.00	25.00	1.25
10	11.00	17.00	1.55
TOTAL	157.00	230.34	1.47
MEAN	15.70	23.03	
STD DEV	4.22	4.28	
RANGE NTC		11.48	19.92
RANGE JANUS		18.75	27.32

NUMBER OF BLUE TOWs KILLED

BATTLE NUMBER	NTC LOSSES	JANUS LOSSES	RATIO
1	4.00	4.00	1.00
2	14.00	18.00	1.29
3	14.00	24.00	1.71
4	9.00	3.67	0.41
5	2.00	5.33	2.67
6	2.00	9.00	4.50
7	4.00	4.00	1.00
8	10.00	11.33	1.13
9	8.00	4.00	0.50
10	10.00	14.67	1.47
TOTAL	77.00	98.00	1.27
MEAN	7.70	9.80	
STD DEV	4.29	6.74	
RANGE NTC		3.41	1.99
RANGE JANUS		3.06	16.54

NUMBER OF BLUE APC KILLED

BATTLE NUMBER	NTC LOSSES	JANUS LOSSES	RATIO
1	5.00	18.00	3.60
2	14.00	18.00	1.29
3	14.00	24.00	1.71
4	13.00	29.00	2.23
5	13.00	35.67	2.74
6	20.00	29.00	1.45
7	19.00	29.00	1.53
8	13.00	29.00	2.23
9	27.00	32.67	1.21
10	29.00	36.67	1.26
TOTAL	167.00	281.01	1.68
MEAN	16.70	28.10	
STD DEV	6.83	6.13	
RANGE NTC		9.87	23.53
RANGE JANUS		21.97	34.23

NUMBER OF BLUE VULCANs KILLED

BATTLE NUMBER	NTC LOSSES	JANUS LOSSES	RATIO
1	3.00	1.00	0.33
2	0.00	1.00	0.00
3	0.00	1.00	0.00
4	3.00	1.00	0.33
5	0.00	1.00	0.00
6	1.00	0.00	0.00
7	3.00	1.00	0.33
8	3.00	1.00	0.33
9	0.00	2.00	0.00
10	3.00	2.00	0.67
TOTAL	16.00	11.00	0.69
MEAN	1.60	1.10	
STD DEV	1.43	0.54	
RANGE NTC		0.17	3.03
RANGE JANUS		0.56	1.64

NUMBER OF BLUE MORTARs KILLED

BATTLE NUMBER	NTC LOSSES	JANUS LOSSES	RATIO
1	3.00	0.00	0.00
2	0.00	0.00	0.00
3	0.00	0.00	0.00
4	0.00	0.00	0.00
5	0.00	0.00	0.00
6	3.00	0.00	0.00
7	1.00	1.00	1.00
8	6.00	0.00	0.00
9	0.00	0.00	0.00
10	3.00	0.00	0.00
TOTAL	16.00	1.00	0.06
MEAN	1.60	0.10	
STD DEV	1.96	0.30	
RANGE NTC		-0.36	3.56
RANGE JANUS		-0.20	0.40

NUMBER OF BLUE COBRAs KILLED

BATTLE NUMBER	NTC LOSSES	JANUS LOSSES	RATIO
1	1.00	5.67	5.67
2	0.00	1.00	0.00
3	0.00	0.00	0.00
4	4.00	12.00	3.00
5	2.00	7.00	3.50
6	0.00	5.00	0.00
7	0.00	0.00	0.00
8	5.00	9.00	1.80
9	0.00	7.00	0.00
10	0.00	5.00	0.00
TOTAL	12.00	51.67	4.31
MEAN	1.20	5.17	
STD DEV	1.78	3.73	
RANGE NTC		-0.58	2.98
RANGE JANUS		1.44	8.90

NUMBER OF RED TANKS KILLED

BATTLE NUMBER	NTC LOSSES	JANUS LOSSES	RATIO
1	10.00	33.67	3.37
2	10.00	24.67	2.47
3	21.00	27.67	1.32
4	14.00	32.33	2.31
5	14.00	28.00	2.00
6	11.00	30.33	2.76
7	15.00	30.00	2.00
8	19.00	28.33	1.49
9	20.00	28.00	1.40
10	28.00	28.67	1.02
TOTAL	162.00	291.67	1.80
MEAN	16.20	29.17	
STD DEV	5.47	2.42	
RANGE NTC		10.73	21.67
RANGE JANUS		26.75	31.58

NUMBER OF RED BMPs KILLED

BATTLE NUMBER	NTC LOSSES	JANUS LOSSES	RATIO
1	10.00	42.33	4.23
2	19.00	28.67	1.51
3	44.00	39.00	0.89
4	24.00	51.00	2.13
5	25.00	42.00	1.68
6	29.00	41.00	1.41
7	26.00	47.00	1.81
8	43.00	53.00	1.23
9	37.00	47.00	1.27
10	54.00	34.67	0.64
TOTAL	311.00	425.67	1.37
MEAN	31.10	42.57	
STD DEV	12.56	7.00	
RANGE NTC		18.54	43.66
RANGE JANUS		35.56	49.57

NUMBER OF RED HOWITZERS KILLED

BATTLE NUMBER	NTC LOSSES	JANUS LOSSES	RATIO
1	1.00	1.00	1.00
2	1.00	0.00	0.00
3	5.00	0.00	0.00
4	0.00	3.33	0.00
5	0.00	3.33	0.00
6	0.00	0.00	0.00
7	4.00	0.00	0.00
8	1.00	1.00	1.00
9	1.00	0.00	0.00
10	4.00	1.00	0.25
TOTAL	17.00	9.66	0.57
MEAN	1.70	0.97	
STD DEV	1.79	1.26	
RANGE NTC		-0.09	3.49
RANGE JANUS		-0.29	2.22

NUMBER OF RED MTLBs KILLED

BATTLE NUMBER	NTC LOSSES	JANUS LOSSES	RATIO
1	2.00	7.00	3.50
2	0.00	2.33	0.00
3	0.00	5.67	0.00
4	0.00	10.33	0.00
5	1.00	5.00	5.00
6	0.00	8.33	0.00
7	1.00	9.00	9.00
8	0.00	7.67	0.00
9	5.00	6.00	1.20
10	6.00	5.33	0.89
TOTAL	15.00	66.66	4.44
MEAN	1.50	6.67	
STD DEV	2.11	2.18	
RANGE NTC		-0.61	3.61
RANGE JANUS		4.49	8.85

NUMBER OF RED ZSU 24 3 KILLED

BATTLE NUMBER	NTC LOSSES	JANUS LOSSES	RATIO RATIO
1	2.00	2.00	1.00
2	1.00	0.00	0.00
3	0.00	2.00	0.00
4	1.00	1.33	1.33
5	1.00	2.00	2.00
6	0.00	3.00	0.00
7	3.00	3.00	1.00
8	2.00	3.67	1.84
9	1.00	2.00	2.00
10	3.00	2.33	0.78
TOTAL	14.00	21.33	1.52
MEAN	1.40	2.13	
STD DEV	1.02	0.96	
RANGE NTC		0.38	2.42
RANGE JANUS		1.18	3.09

NUMBER OF RED BRDMs KILLED

BATTLE NUMBER	NTC LOSSES	JANUS LOSSES	RATIO RATIO
1	1.00	0.33	0.33
2	0.00	0.00	0.00
3	1.00	0.00	0.00
4	1.00	0.00	0.00
5	0.00	0.00	0.00
6	2.00	0.00	0.00
7	2.00	0.00	0.00
8	2.00	0.00	0.00
9	3.00	0.00	0.00
10	0.00	0.00	0.00
TOTAL	12.00	0.33	0.03
MEAN	1.20	0.03	
STD DEV	0.98	0.10	
RANGE NTC		0.22	2.18
RANGE JANUS		-0.07	0.13

NUMBER OF RED HINDs KILLED

BATTLE NUMBER	NTC LOSSES	JANUS LOSSES	RATIO
1	0.00	0.00	0.00
2	1.00	2.00	2.00
3	0.00	0.00	0.00
4	0.00	0.00	0.00
5	0.00	4.00	0.00
6	1.00	4.00	4.00
7	1.00	6.00	6.00
8	2.00	4.00	2.00
9	1.00	4.00	4.00
10	0.00	4.00	0.00
TOTAL	6.00	28.00	4.67
MEAN	0.60	2.80	
STD DEV	0.66	2.04	
RANGE NTC		-0.06	1.26
RANGE JANUS		0.76	4.84

APPENDIX E

RED AND BLUE LOSSES ATTRIBUTED TO SPECIFIC WEAPON SYSTEMS

Appendix E contains the data used in this thesis for the number of losses per weapon system which are attributed to another specific weapon system.

NUMBER OF RED TANKS KILLED BY BLUE TANKS

BATTLE NUMBER	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	NTC LOSSES	RATIO JANUS TO NTC
1	21	22	20	21.00	9.00	2.33
2	16	16	15	15.67	7.00	2.24
3	15	15	15	15.00	15.00	1.00
4	15	15	21	17.00	11.00	1.55
5	14	14	14	14.00	10.00	1.40
6	15	15	15	15.00	8.00	1.88
7	21	21	21	21.00	6.00	3.50
8	12	17	15	14.67	10.00	1.47
9	18	18	18	18.00	14.00	1.29
10	11	13	13	12.33	22.00	0.56
		TOTAL		163.67	112.00	1.46
		MEAN		16.37	11.20	
		STD DEV		2.74	4.49	

RANGE FOR JANUS:	13.63	TO	19.11
RANGE FOR NTC:	6.71	TO	15.69

NUMBER OF BLUE TANKS KILLED BY RED TANKS

BATTLE NUMBER	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	NTC LOSSES	RATIO JANUS TO NTC
1	6	6	6	6.00	4.00	1.50
2	11	12	13	12.00	12.00	1.00
3	11	11	11	11.00	9.00	1.22
4	5	5	6	5.33	12.00	0.44
5	6	6	3	5.00	3.00	1.67
6	2	2	2	2.00	2.00	1.00
7	5	5	5	5.00	9.00	0.56
8	7	4	11	7.33	3.00	2.44
9	9	9	9	9.00	8.00	1.13
10	5	7	7	6.33	5.00	1.27
		TOTAL		69.00	67.00	1.03
		MEAN		6.90	6.70	
		STD DEV		2.87	3.58	

RANGE FOR JANUS: 4.03 TO 9.77
RANGE FOR NTC: 3.12 TO 10.28

NUMBER OF RED TANK KILLED BY BLUE TOW

BATTLE NUMBER	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	NTC LOSSES	RATIO JANUS TO NTC
1	7	7	7	7.00	1.00	7.00
2	6	4	5	5.00	2.00	2.50
3	11	10	11	10.67	1.00	10.67
4	12	12	10	11.33	1.00	11.33
5	9	9	11	9.67	3.00	3.22
6	11	11	11	11.00	3.00	3.67
7	8	8	8	8.00	4.00	2.00
8	10	5	8	7.67	6.00	1.28
9	6	6	6	6.00	4.00	1.50
10	6	8	8	7.33	4.00	1.83
	TOTAL			83.67	29.00	2.89
	MEAN			8.37	2.90	
	STD DEV			2.08	1.58	

RANGE FOR JANUS: 6.29 TO 10.45
RANGE FOR NTC: 1.32 TO 4.48

NUMBER OF BLUE TOWS KILLED BY RED TANKS

BATTLE NUMBER	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	NTC LOSSES	RATIO JANUS TO NTC
1	0	0	0	0.00	0.00	0.00
2	1	1	1	1.00	5.00	0.20
3	0	0	0	0.00	0.00	0.00
4	0	0	0	0.00	4.00	0.00
5	0	0	0	0.00	1.00	0.00
6	0	0	0	0.00	0.00	0.00
7	0	0	0	0.00	2.00	0.00
8	0	0	0	0.00	6.00	0.00
9	0	0	0	0.00	3.00	0.00
10	0	0	0	0.00	6.00	0.00
		TOTAL		1.00	27.00	0.04
		MEAN		0.10	2.70	
		STD DEV		0.30	2.33	
RANGE FOR JANUS:			-0.20	TO	0.40	
RANGE FOR NTC:			0.37	TO	5.03	

NUMBER OF RED BMP KILLED BY BLUE TANKS

BATTLE NUMBER	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	NTC LOSSES	RATIO JANUS TO NTC
1	27	29	26	27.33	12.00	2.28
2	6	6	5	5.67	18.00	0.31
3	16	16	16	16.00	33.00	0.48
4	28	28	18	24.67	20.00	1.23
5	10	10	16	12.00	16.00	0.75
6	15	15	15	15.00	19.00	0.79
7	16	16	16	16.00	16.00	1.00
8	12	16	7	11.67	27.00	0.43
9	9	9	9	9.00	29.00	0.31
10	5	5	5	5.00	32.00	0.16
	TOTAL			142.33	222.00	0.64
	MEAN			14.23	22.20	
	STD DEV			6.96	7.04	

RANGE FOR JANUS: 7.27 TO 21.20
RANGE FOR NTC: 15.16 TO 29.24

NUMBER OF BLUE TANKS KILLED BY RED BMP

BATTLE NUMBER	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	NTC LOSSES	RATIO JANUS TO NTC
1	9	11	9	9.67	12.00	0.81
2	16	14	13	14.33	17.00	0.84
3	18	18	18	18.00	9.00	2.00
4	20	20	18	19.33	5.00	3.87
5	18	18	23	19.67	3.00	6.56
6	14	14	14	14.00	5.00	2.80
7	22	22	22	22.00	3.00	7.33
8	18	19	14	17.00	7.00	2.43
9	16	16	16	16.00	4.00	4.00
10	12	10	10	10.67	13.00	0.82
		TOTAL		160.67	78.00	2.06
		MEAN		16.07	7.80	
		STD DEV		3.75	4.56	

RANGE FOR JANUS:	12.31	TO	19.82
RANGE FOR NTC:	3.24	TO	12.36

NUMBER OF RED BMP KILLED BY BLUE TOWS

BATTLE NUMBER	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	NTC LOSSES	RATIO JANUS TO NTC
1	3	3	3	3.00	1.00	3.00
2	19	16	13	16.00	0.00	0.00
3	14	10	14	12.67	3.00	4.22
4	13	13	19	15.00	0.00	0.00
5	18	18	17	17.67	5.00	3.53
6	17	11	11	13.00	6.00	2.17
7	19	19	19	19.00	2.00	9.50
8	24	25	31	26.67	5.00	5.33
9	27	27	27	27.00	5.00	5.40
10	25	19	19	21.00	18.00	1.17
	TOTAL			171.00	45.00	3.80
	MEAN			17.10	4.50	
	STD DEV			6.70	4.96	

RANGE FOR JANUS: 10.40 TO 23.80
RANGE FOR NTC: -0.46 TO 9.46

NUMBER OF BLUE TOW KILLED BY RED BMP

BATTLE NUMBER	JANUS LOSSES RUN 1	JANUS LOSSES RUN 2	JANUS LOSSES RUN 3	AVG JANUS LOSSES	NTC LOSSES	RATIO JANUS TO NTC
1	4	4	4	4.00	4.00	1.00
2	4	2	4	3.33	1.00	3.33
3	4	4	4	4.00	1.00	4.00
4	4	4	3	3.67	5.00	0.73
5	4	4	5	4.33	0.00	0.00
6	9	9	9	9.00	1.00	9.00
7	3	3	3	3.00	2.00	1.50
8	10	13	11	11.33	4.00	2.83
9	3	3	3	3.00	5.00	0.60
10	14	15	15	14.67	2.00	7.33
		TOTAL		60.33	25.00	2.41
		MEAN		6.03	2.50	
		STD DEV		3.92	1.75	

RANGE FOR JANUS: 2.11 TO 9.96
RANGE FOR NTC: 0.75 TO 4.25

APPENDIX F

TOTAL LOSSES FOR ALL TEN BATTLES

Appendix F contains the data used in this thesis for the sum total of the ten battles of the number of red and blue force losses by weapon system.

TOTAL RED FORCE LOSSES

WEAPON SYSTEM	NTC LOSSES	JANUS LOSSES	RATIO
TANKS	162.00	291.67	1.80
BMP	311.00	425.67	1.37
BRDM	12.00	0.33	0.03
MTLB	15.00	9.67	0.64
HOW 122	17.00	66.67	3.92
ZSU	14.00	21.33	1.52
HIND	6.00	28.00	4.67
TOTAL	537.00	843.34	1.57
MEAN	53.70	84.33	
STD DEV	97.48	141.75	

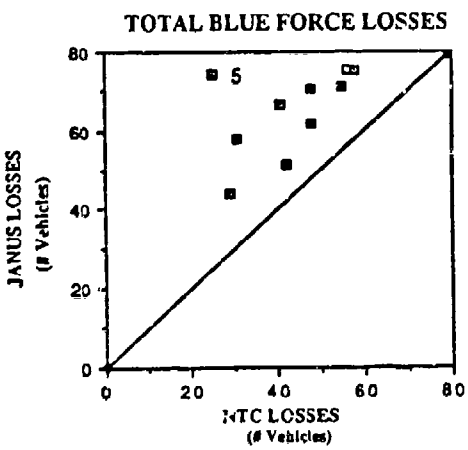
TOTAL BLUE FORCE LOSSES

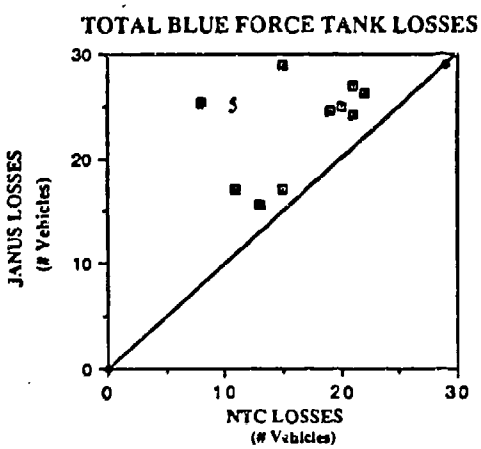
WEAPON SYSTEM	NTC LOSSES	JANUS LOSSES	RATIO
TANKS	157.00	230.34	1.47
APC	167.00	218.01	1.31
TOW	77.00	98.00	1.27
MORTAR	16.00	1.00	0.06
VULCAN	16.00	11.00	0.69
COBRA	12.00	51.67	4.31
TOTAL	445.00	610.02	1.37
MEAN	44.50	61.00	
STD DEV	62.71	87.04	

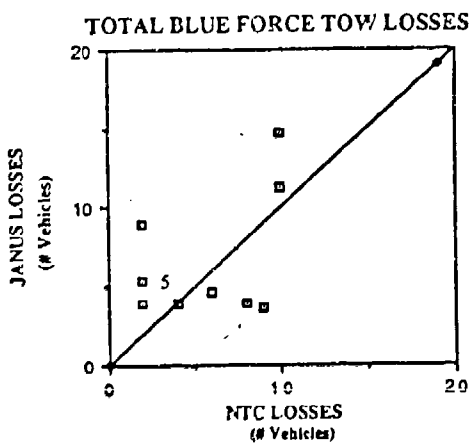
APPENDIX G

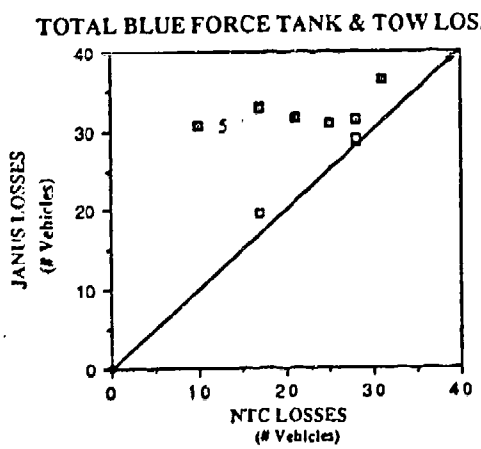
SCATTER PLOTS

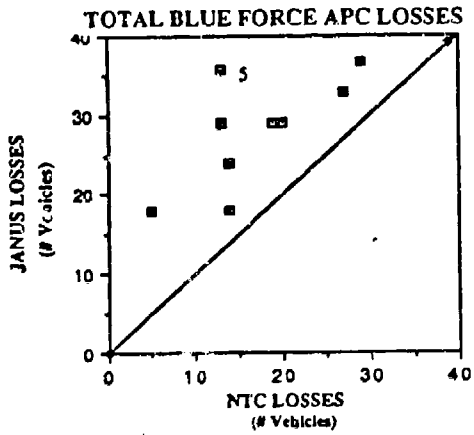
Appendix G contains the scatter plots of the seventeen comparisons of the JANUS (T) model and the NTC battle results used for analysis in this thesis.

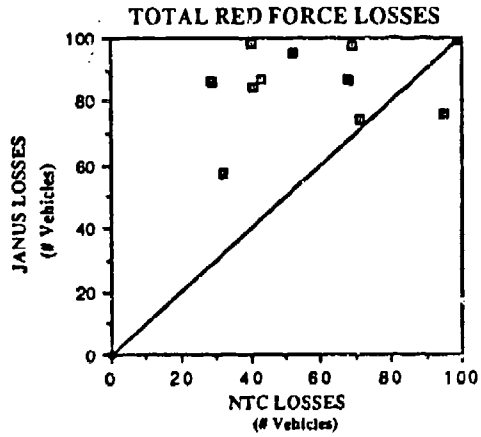

TOTAL BLUE FORCE LOSSES
JANUS LOSSES
(# Vehicles)
NTC LOSSES
(# Vehicles)
0
20
40
60
80
5

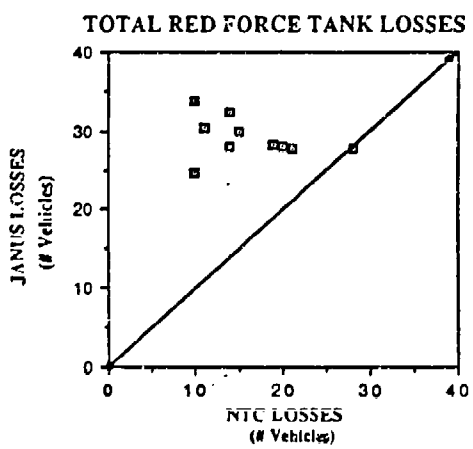

TOTAL BLUE FORCE TANK LOSSES
JANUS LOSSES
(# Vehicles)
NTC LOSSES
(# Vehicles)
0
10
20
30
5

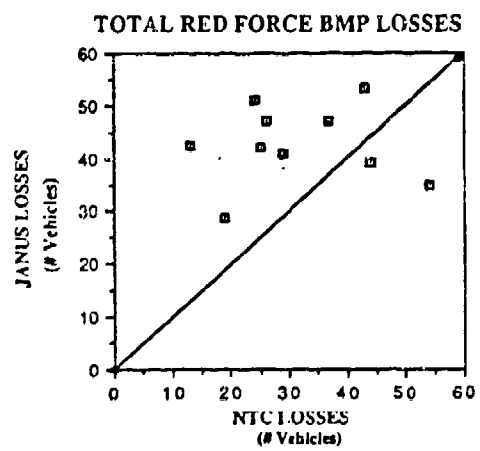

TOTAL BLUE FORCE TOW LOSSES
JANUS LOSSES
(# Vehicles)
NTC LOSSES
(# Vehicles)
0
10
20
5


TOTAL BLUE FORCE TANK & TOW LOSSES
JANUS LOSSES
(# Vehicles)
NTC LOSSES
(# Vehicles)
0
10
20
30
40
5

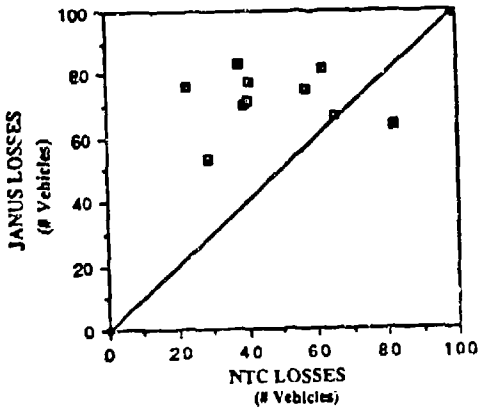

TOTAL BLUE FORCE APC LOSSES
JANUS LOSSES
(# Vehicles)
NTC LOSSES
(# Vehicles)
0
10
20
30
40


TOTAL RED FORCE LOSSES
JANUS LOSSES
(# Vehicles)
NTC LOSSES
(# Vehicles)
0
20
40
60
80
100

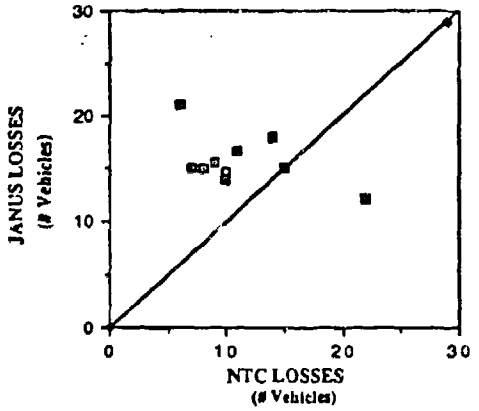

TOTAL RED FORCE TANK LOSSES
JANUS LOSSES
(# Vehicles)
NTC LOSSES
(# Vehicles)
0
10
20
30
40


TOTAL RED FORCE BMP LOSSES
JANUS LOSSES
(# Vehicles)
NTC LOSSES
(# Vehicles)
0
10
20
30
40
50
60

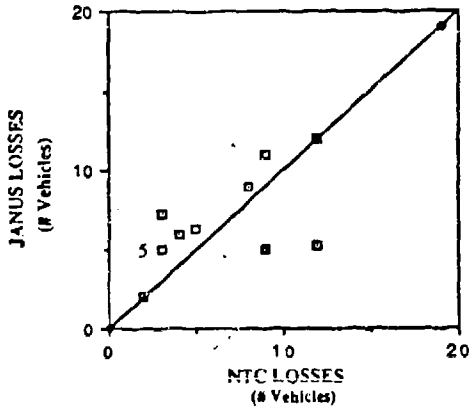
TOTAL RED FORCE TANK & BMP LOSSES



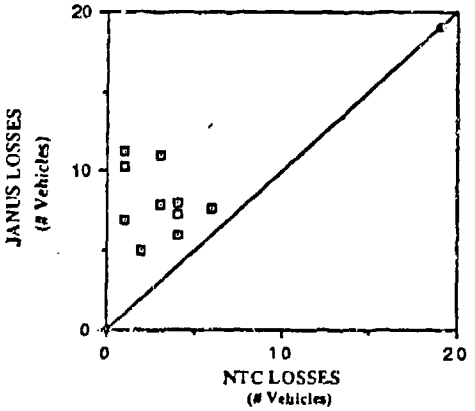
RED TANKS KILLED BY BLUE TANKS



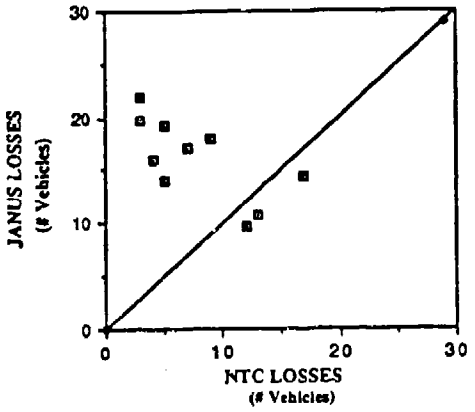
BLUE TANKS KILLED BY RED TANKS



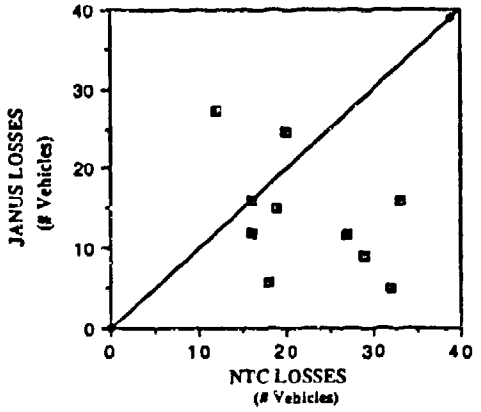
RED TANKS KILLED BY BLUE TOWS



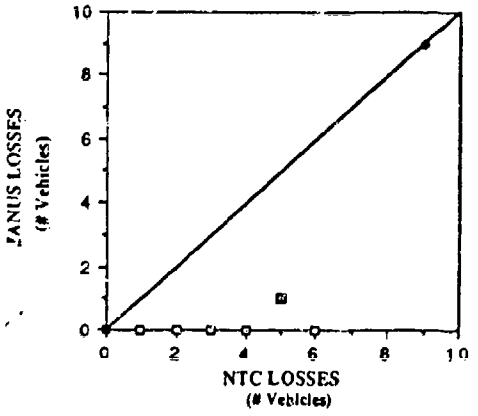
BLUE TANKS KILLED BY RED BMPS

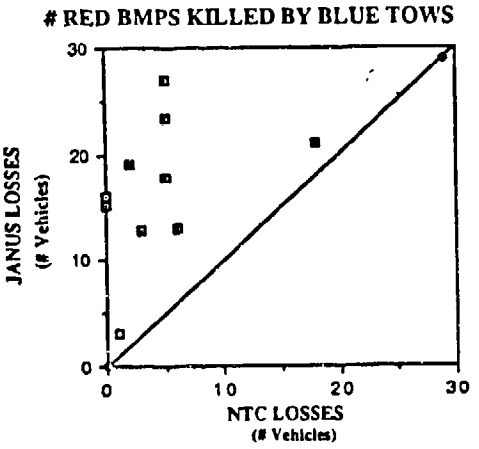


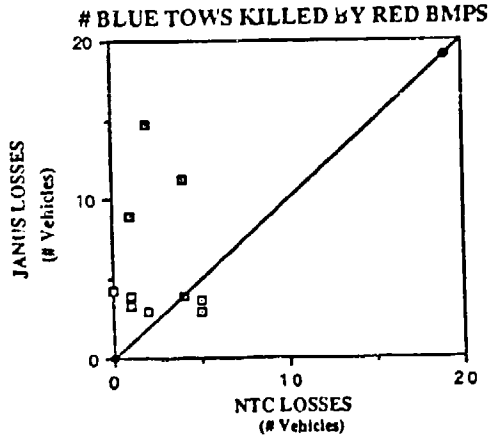
RED BMPS KILLED BY BLUE TANKS



BLUE TOWS KILLED BY RED TANKS




RED BMPS KILLED BY BLUE TOWS
JANUS LOSSES
(# Vehicles)
30
20
10
0
0
10
20
30
NTC LOSSES
(# Vehicles)

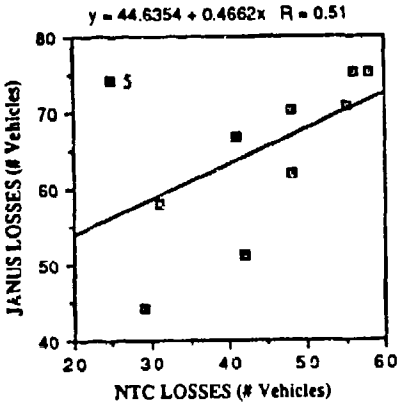

BLUE TOWS KILLED BY RED BMPS
JANUS LOSSES
(# Vehicles)
20
10
0
0
10
20
NTC LOSSES
(# Vehicles)

APPENDIX H

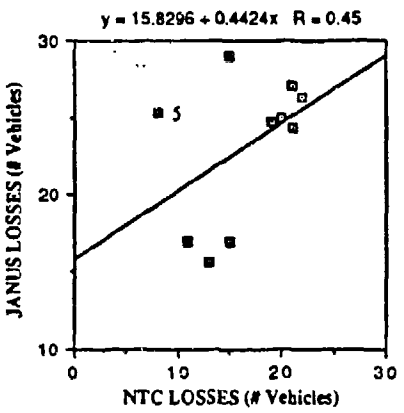
REGRESSION (ALL POINTS INCLUDED)

Appendix H contains the regression plots of the seventeen comparisons of the JANUS (T) model and the NTC battle results used for analysis in this thesis.

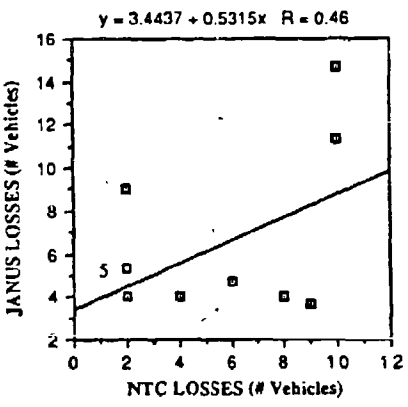
REGRESSION OF
TOTAL BLUE FORCE LOSSES



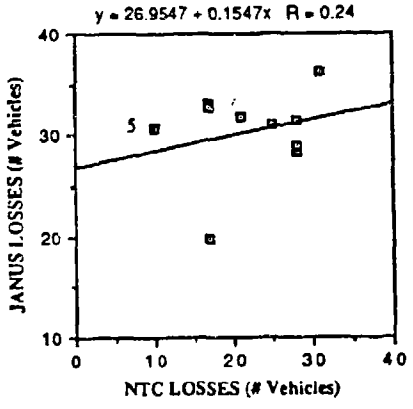
REGRESSION OF
TOTAL BLUE TANK LOSSES



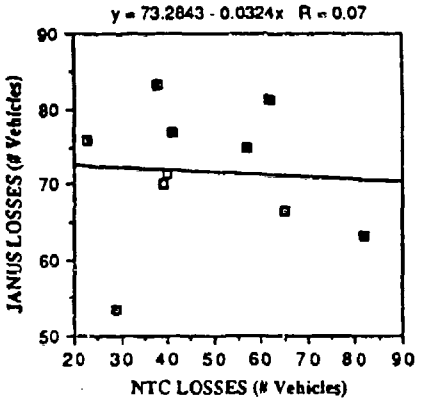
REGRESSION OF
TOTAL BLUE TOW LOSSES



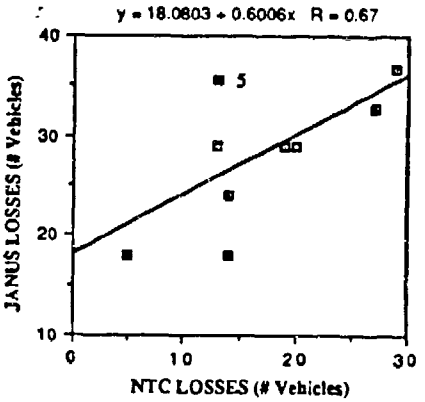
REGRESSION OF
TOTAL BLUE FORCE TANK & TOW LOSSES



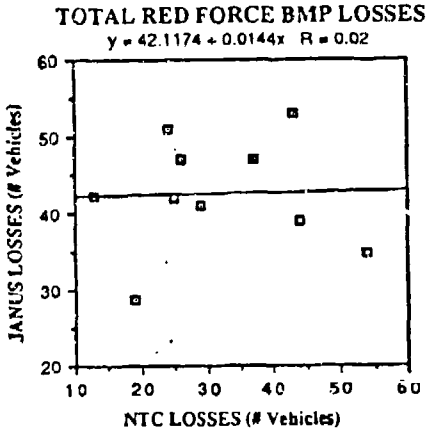
REGRESSION OF
TOTAL RED TANK & BMP LOSSES



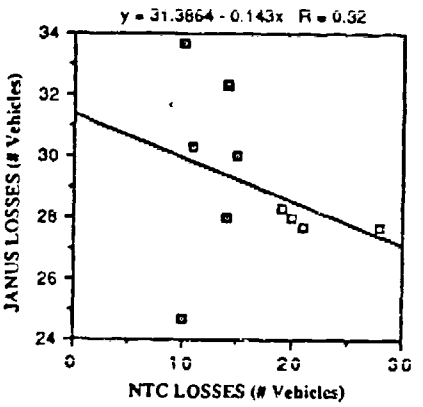
REGRESSION OF
TOTAL BLUE FORCE APC LOSSES



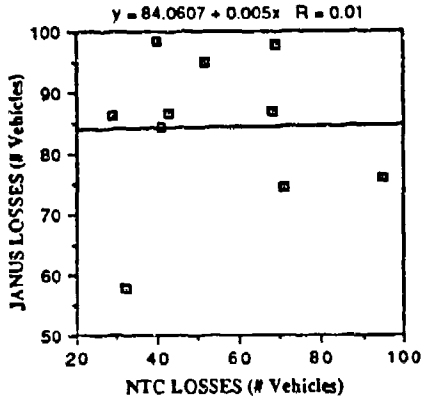
REGRESSION OF
TOTAL RED FORCE BMP LOSSES



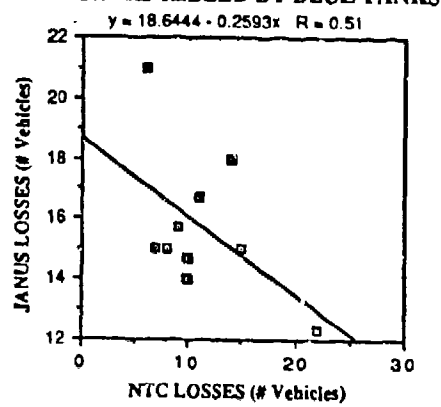
REGRESSION OF
TOTAL RED FORCE TANK LOSSES



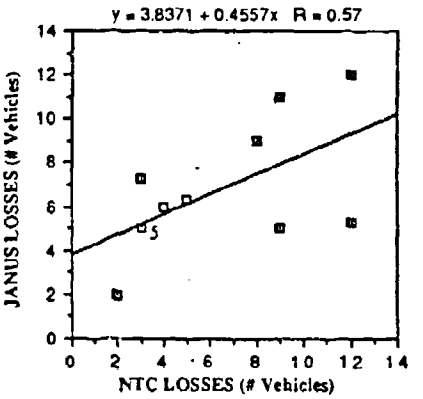
REGRESSION OF
TOTAL RED FORCE LOSSES



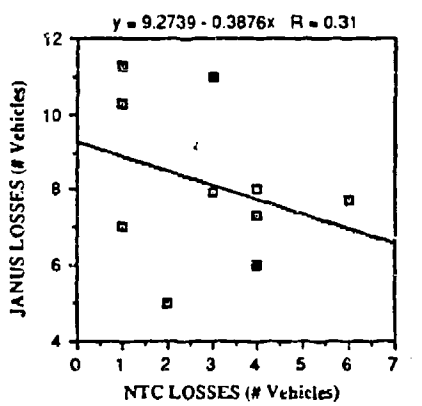
REGRESSION OF
RED TANKS KILLED BY BLUE TANKS



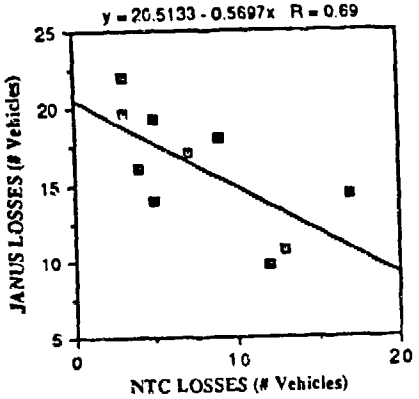
REGRESSION OF
BLUE TANKS KILLED BY RED TANKS



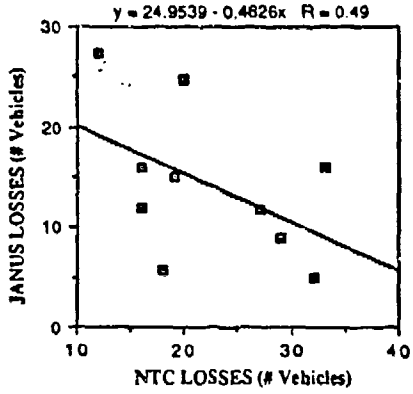
REGRESSION OF
RED TANKS KILLED BY BLUE TOWS



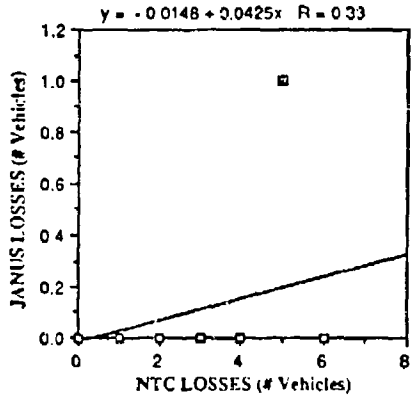
REGRESSION OF
BLUE TANKS KILLED BY RED BMPS



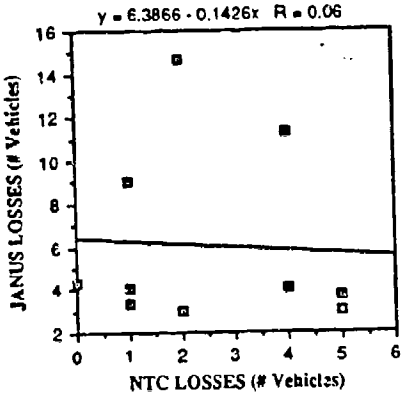
REGRESSION OF
RED BMPS KILLED BY BLUE TANKS



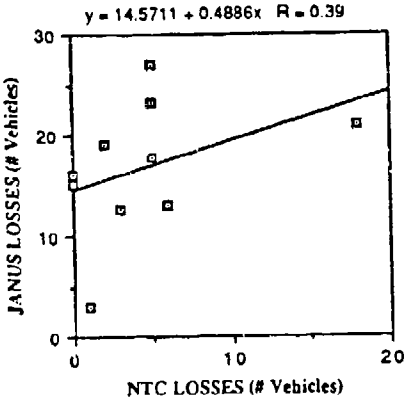
REGRESSION OF
BLUE TOWS KILLED BY RED TANKS



REGRESSION OF
BLUE TOWS KILLED BY RED BMPS



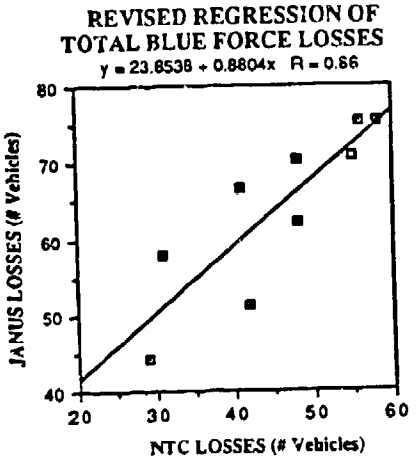
REGRESSION OF
RED BMPS KILLED BY BLUE TOWS

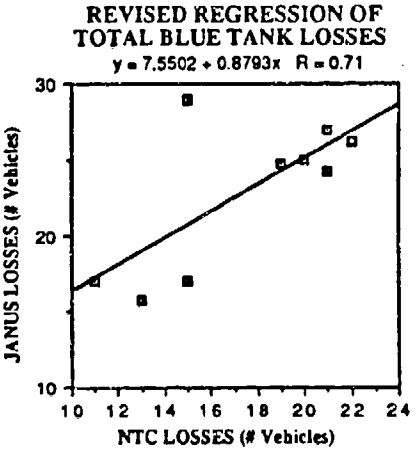


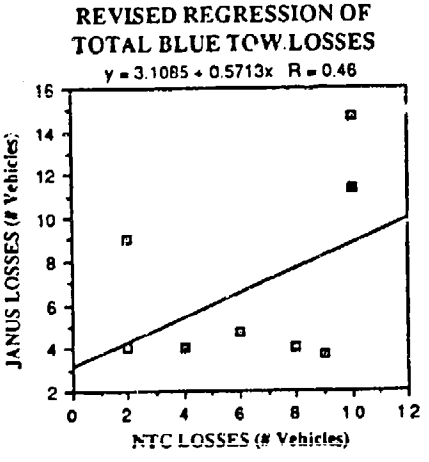
APPENDIX I

REVISED REGRESSION (FIFTH BATTLE DELETED)

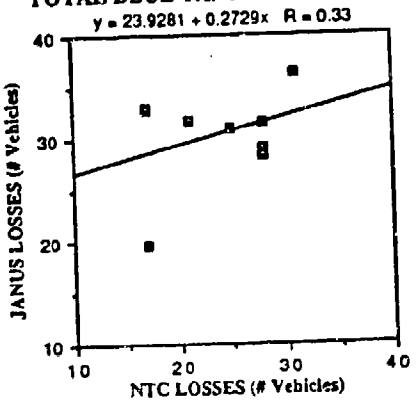
Appendix I is the revised regression plots (battle number five was deleted) of the seventeen comparisons of the JANUS (T) model and the NTC battle results used for analysis in this thesis.


REVISED REGRESSION OF
TOTAL BLUE FORCE LOSSES
y = 23.8538 + 0.8804x R = 0.66
JANUS LOSSES (# Vehicles)
NTC LOSSES (# Vehicles)
80
70
60
50
40
20
30
40
50
60

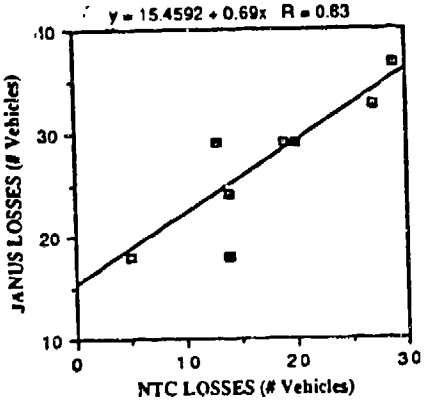

REVISED REGRESSION OF
TOTAL BLUE TANK LOSSES
y = 7.5502 + 0.8793x R = 0.71
JANUS LOSSES (# Vehicles)
NTC LOSSES (# Vehicles)
30
20
10
10
12
14
16
18
20
22
24


REVISED REGRESSION OF
TOTAL BLUE TOW LOSSES
y = 3.1085 + 0.5713x R = 0.46
JANUS LOSSES (# Vehicles)
NTC LOSSES (# Vehicles)
16
14
12
10
8
6
4
2
0
2
4
6
8
10
12

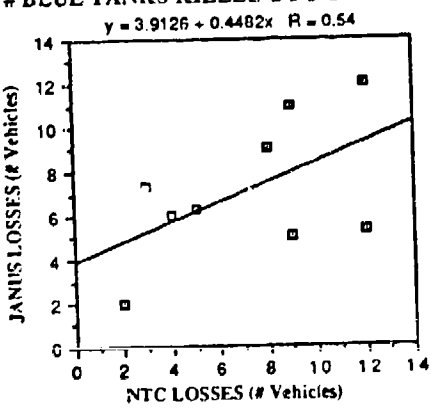
REVISED REGRESSION OF
TOTAL BLUE TANK & TOW LOSSES



REVISED REGRESSION OF
TOTAL BLUE APC LOSSES



REVISED REGRESSION OF
BLUE TANKS KILLED BY RED TANKS



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